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THE JOURNAL

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A Revision of the Genera and great Groups of the Echinoidea.

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[Read 7th February, 1889.]

I.

Introduction:—the necessity for a Revision of the Fossil and Recent Genera of the Class Echinoidea and for a reconsideration of the arrangement of the great groups.—Definition of the Class Echinoidea and of its Subclasses the Palæechinoidea and the Euechinoidea. Remarks upon the Palæechinoidea, their Classification.—Definitions of the Orders and Genera.

THE last work of L. Agassiz and Desor, "Le Catalogue Raisonné des Familles, Genres, et des Espèces de la Classe des Échinides," was published in the 'Annales des Sciences Naturelles' during 1846–7, and was a magnificent conspectus of all their previous labours in the classification of both the fossil and the recent Echinoidea. The work formed the foundation of a vast superstructure, which, however, soon separated into studies of the fossil species and genera apart from those of the recent fauna. Desor gathered together all the information regarding the fossil forms up to 1858, when he published his 'Synopsis des Échinides fossiles.' This standard work has been of great value to palæontologists. The history of the Zoology of the recent Echinoidea, subsequently to the date of the 'Catalogue Raisonné' and up to 1883, and also a previous 'Revision of the Echini' (1872–4) were the contributions of Alexander Agassiz. The Reports on the Echini of the 'Hassler,' 1874, 'Challenger,' 1881, and 'Blake,

1883, Expeditions, by this author, contain nearly the whole of the systematic and much of the morphological knowledge of the recent fauna. The work of Desor, and those of A. Agassiz, the one on the fossil, and the others mainly on the recent genera and species, are invaluable and have formed the basis of all subsequent research. But no book has appeared which has been written by any naturalist who has personally laboured in the classification and morphology of the Class, which has treated of both the fossil and the recent genera. Palæontologists have published great numbers of genera and species since the days of Desor, and have not invariably paid attention to the progress of their fellow workers who have described recent forms. And, on the other hand, much that was written a few years since by some naturalists, dealing with recent forms, would not have seen the light had careful descriptions of fossil genera, such, for instance, as have been published by Cotteau, de Loriol, and Sven Lovén, been available in a standard work of reference. The results of this division of labour and of the independent researches of Palæontologists and Zoologists have been the adoption of too many genera and the production of much confusion in the nomenclature; and the recognition of genera and species, both fossil and recent, has been rendered difficult by the publication of their diagnoses in the Journals of learned Societies, and in the works of Geological Surveys of nearly every civilized country.

The progress of the morphology of the recent Echinoidea has been great, and it chiefly dates from the time of J. Müller (1854) and the subsequent publication of S. Lovén's 'Études sur les Échinoïdées' in 1874; it was maintained by the author of the 'Revision of the Echini,' and much valuable new matter is to be found in the 'Challenger' and 'Blake' Reports. Lovén's wonderful work on *Pourtalesia* and his later contributions, together with the results of the work of Sir Wy. Thomson, and of Messrs. Norman, Stewart, Ludwig, H. Carpenter, Sladen, Hamann, Sarasin, and Bell, and of some publications in the Journals of the Linnean and Geological Societies of London, have rendered some modifications in the terminology and of the taxonomic value of certain structures absolutely necessary. It is the belief of all practical Echinologists that a work which would collect the generic descriptions of both the fossil and recent faunas, and which would revise and eliminate when necessary, by the light of modern morphology, is very

urgently required. Hence in this "Revision of the Genera and great Groups of the Fossil and Recent Echinoidea," the Author has endeavoured to remedy an urgent want. He has had unusual advantages and opportunities for studying fossil and recent Echinoidea; and in this endeavour to utilize them he is under great obligations to his friend A. Agassiz and to the able naturalists and palæontologists connected with the British Museum, the Museum of Practical Geology, the Woodwardian Museum at Cambridge, to his colleague in the description of the Sindian Fauna, Mr. Percy Sladen, and last, but by no means least, to his kind and generous friend Sven Lovén.

NOTE.—It will be noticed that many genera no longer find a place in the classification, but are either removed entirely or placed as subgenera, and, as the intention was to limit the genera rigidly, very few new ones are introduced. In describing every genus, the name which comes immediately after the generic term is that of the founder, and when it is in roman type it may be as sumed that the original definition was improved by the naturalist whose name stands next. The names placed after the first one, even when this is not in roman type, are those of subsequent investigators and describers of species who have added to the value or have modified the original diagnosis of the genus. When any anatomical details have been described relating to a genus, the name of the investigator has been added. The references, as a general rule, refer to the date, volume, and page of works in which there are illustrations; but, to save space, the number of the plate is not given, especially as it will be found upon the page referred to. The distribution of the genera has, of necessity, been considered, but the great geological formations alone are noticed in dealing with the fossil forms. A description of the terms employed in the classification will be found at the end of the Essay.

The synonymy adopted by A. Agassiz in his 'Revision of the Echini,' 1872–1874, is accepted.

The classification of Dujardin et Hupé, in 'Les Suites à Buffon,' was a useful but not critical literary work, being a compilation. M. Pomel's "Thèses," Algiers, 1883, contain a classification which is not followed in this communication, for the fundamental methods employed do not commend themselves, it being impossible to admit genera which are not differentiated by characters which have a decided and important physiological value.

Subkingdom ECHINODERMATA.

Class ECHINOIDEA.

Echinodermata with a solid or slightly flexible test covering the viscera, variable in shape from spheroidal to flat, composed of numerous, closely placed, more or less geometrical plates of carbonate of lime, covered with soft structures and carrying spines. Most of the plates arranged in several vertical series, reaching from the mouth to the dorso-central or apical system, constituting five ambulacral and five interradial areas. Other plates in the dorso-central system—the basal and radial and anal plates. With a mouth on the under or actinal surface, rarely in front of the test, and an internal gullet and intestinal tract ending externally in an anus, which is either placed in the dorso-central system or somewhere in the posterior interradium. A madreporite body placed in the dorso-central system and in relation with a renal organ and with the water-system, which is partly within the test and partly external, in the form of branchiæ and branchial tentacles. With or without five teeth in jaw-pieces, which are moved by muscles connected with a connected or disconnected perignathic girdle.

Unisexual or bisexual; the genital glands with ducts perforating the basal plates or opening beyond them; the young, either undergoing metamorphoses and being free-swimmers, or found perfect upon the parent's test.

Marine: fossil and recent.

I. Subclass. The PALÆECHINOIDEA, *Zittel* (amended).

Echinoidea with only one, or with more than two, vertical rows of plates in each of the five interradia, and with either two or many vertical rows of simple or compound plates in each of the five ambulacra; plates of the areas overlapping or not. Peristome actinal. Jaws present. Periproct within the dorso-central system or in the posterior interradium beyond.

II. Subclass. The EUECHINOIDEA, *Bronn*.

Echinoidea with two vertical rows of plates in each of the five interradia, and a similar number of vertical rows of simple or of compound plates in each of the five ambulacra. Peristome actinal,

rarely anterior; jaws and teeth present or absent. Periproct either within the dorso-central system or in the posterior inter-radium.

I. Subclass *PALÆECHINOIDEA.*

The Palæechinoidea have gradually become a great group which is readily separable from all the other divisions of the Echinoidea. The first careful descriptions of its genera and species were given by McCoy in his "Description of the Carboniferous Fossils of Ireland;" subsequently Baily, Meek and Worthen, Hall, and J. Müller added greatly to the knowledge of the anatomy and taxonomy. In 'Les Études,' Sven Lovén summarized the information which had been obtained up to 1874 and mainly followed McCoy's classification. About the same time A. Agassiz gave some important notices of the Perischoechinidæ, McCoy, then the only group of Palæechinoidea, in the 'Revision of the Echini' (p. 644). In the course of his observations A. Agassiz criticised the classifications of previous authors, and very properly drew especial attention to the discovery of J. Müller regarding the overlapping of the coronal plates of some genera, and he compared this phenomenon with the imbrication of the peristomial plates of *Cidaris* and of the coronal plates of the Echinothuridæ. It became evident that a new taxonomy of the group was necessary, and Messrs. R. Etheridge, Junr., and W. Keeping contributed papers (1874–6) to the Geological Society of London, in which the limits of the new classification were fairly stated.

Discoveries of some remarkable forms, such as *Bothriocidaris*, Schmidt, 1874, *Tiarechinus*, Neumayr, 1881, and the reconsideration of *Echinocystites*, Wy. Thomson, 1861, necessitated the introduction of groups which could not be placed as Perischoechinidæ. Zittel gave an admirable classification in his 'Palæontologie,' 1876–80; and finally A. Agassiz introduced some pages in his Report on the 'Challenger' Echini, 1881, which are full of most valuable matter. He had the opportunity of studying the rare species described by American palæontologists, of which plates and figures alone have been noticed by European geologists, and he brought to bear on their consideration a vast amount of knowledge about the recent Echini and especially of the Echion-

thuridæ. The descriptions of some genera by Meek and Worthen and McCoy require additions, in consequence of this work of A. Agassiz.

The foundation of a classification upon the presence or absence of primary tubercles upon tests was due to McCoy, and it served its time; but it was too artificial and permitted genera to be closely associated which had structural differences of great physiological importance. For instance, some genera with two and with more than two vertical rows of ambulacral plates were associated closely; moreover, genera which had bevelled plate-edges, and where there was overlap, were associated with forms which had rigid tests and no overlap of plates. It must be admitted that too much has been made of the presumed and real imbrication of plates in classification.

Whilst it is undeniable that our knowledge of the genera of Palæechinoidea has increased, it is still necessary to remember that any classification must be open to exception. It is not possible to place some of the genera in the same groups upon the admitted principle of the preponderating taxonomic value of the structure of the ambulacra, and, indeed, there must be some anomalous genera; but the following grouping is suggested as the best at the present time.

All genera founded in reference to single plates or spines are not considered, and *Eocidaris*, Keyserl., is omitted, for it is a true Cidarid. *Palæocidaris*, Beyr., is synonymous with *Lepidocentrus*, J. Müller. *Perischocidaris*, Neum., is the same as *Perischodomus*, McCoy. *Echinocrinus*, Ag., and *Palæocidaris*, Desor, are synonymous with *Archæocidaris*, McCoy. *Protoechinus*, Aust., is the same as *Palæechinus*, Scoul. *Melechinus* is *Melonites*, Norw. & Owen. *Cystocidaris*, Zitt., is *Echinocystites*, Wy. Th. *Palæodiscus*, Salter, which was intended for an Asterid genus, really contains some Echinoidean types closely resembling *Echinocystites*; but the position of the periproct is not known.

The genera remaining after these removals and absorptions are classified under four orders of the subclass Palæechinoidea. *Bothriocidaris*, a remarkable form from the Lower Silurian formation, requires, as Zittel has shown, a special group, and an order is established for it. The Perischoechinoida group themselves with as little friction as possible into two families, the Archæocidaridæ, with narrow ambulacra, and the Melonitidæ, with more than two vertical rows of poriferous plates in an

ambulacrum. *Tiarechinus*, so ably described by Lovén after Neumayr, is unique and must enter an order of its own. And, finally, the exocyclic *Echinocystites* comes into the order Cystocidaroida.

It is certainly supremely interesting to find jaws and teeth in these old forms and to be able to classify, thanks to Sir Wy. Thomson, an exocyclic gnathostome amongst the Palæozoic Echinoidea.

Classification.

SUBCLASS PALÆECHINOIDEA. (Page 5.)

ORDER I. BOTHRIOCIDAROIDA.

Genus *Bothriocidaris*, Schmidt.

ORDER II. PERISCHOECHINOIDA.

Family ARCHÆOCIDARIDÆ.

Genus *Lepidocentrus*, J. Müller.
Koninckocidaris, Dollo & Buisseret.
Perischodomus, McCoy.
Archæocidaris, McCoy.
Lepidocidaris, Meek & Worthen.
Lepidechinus, Hall.
Palæechinus (Scouler), McCoy (pars).
Rhoechinus, W. Keeping.

Family MELONITIDÆ.

Genus *Melonites*, Norwood and Owen.
Oligoporus, Meek & Worthen.
Lepidesthes, Meek & Worthen.
Hybochinus, Worthen & Miller.
Pholidocidaris, Meek & Worthen.

ORDER III. PLESIOCIDAROIDA.

Genus *Tiarechinus*, Neumayr.

ORDER IV. CYSTOCIDAROIDA.

Genus *Echinocystites*, Wy. Thomson, 1861.

Order I. BOTHRIOCIDAROIDA,
F. Schmidt, 1874; *Zittel*, 1876–80.

Test regular, more or less spherical, solid; interradia with only one vertical row of plates which do not imbricate; ambulacra with two vertical rows of plates; plates united at their edges. Periproct in the central apical system. Peristome actinal, central. Jaws ?

Genus Bothriocidaris, Eichwald, 1860, *Lethæa Rossica*, p. 654. *Fr. Schmidt*, 1874, *Mém. Acad. St. Pétersb.* sér. 7, vol. xxi. no. xi. pp. 36–38. *Zittel*, 1876–80, *Palæont.* Bd. i. p. 481. *Lovén*, 1883, *Pourtalesia*, p. 57. (*Slightly altered.*)

Test small, hemispherical or conico-hemispherical.

Apical system central dorsal, with five large broad radial plates limiting the periproct, each with two pores surrounded by a raised rim, with five small, imperforate, triangular basal plates intervening between the radial plates, entering or not the periproct. Six or eight ovoid, acuminate anal plates, each with a spiniferous tubercle.

Ambulacra wider than the interradia, straight, with two rows of plates, large, hexagonal at the ambitus, and smaller above and below; each plate with a central circular pit, with a pair of pores on its floor, and with 2–4 small, perforate, wart-like tubercles, carrying finely longitudinally-striated small spines; around is some granulation. The ambulacra end dorsally at the large radial plates and actinally at the peristomial margin, where they are moderately broad and exclude, by their contact, the interradial plates.

Tentacles long and cylindrical. (*Lovén.*)

Interradia five in number, narrow, composed each of one row of plates subequal to the ambulacral, but smaller dorsally and actinally, excluded from the peristomial margin. Plates may have small tubercles and granules.

Peristome subcircular, margin formed by the ambulacra; five narrow triangular buccal plates project inwards.

Fossil. Lower Silurian: Europe.

Order II. PERISCHOECHINOIDA, *McCoy*, 1849, *Ann. & Mag. Nat. Hist.* vol. iii. (*Amended.*)

Tests regular, with more than two vertical rows of interradial plates which are dissimilar; with two or many vertical rows of ambulacral plates, each with a pair of pores. Test thick and rigid, or thinner and with the plates overlapping more or less. Ornamentation variable. Jaws present.

Family Archæocidaridæ.

Perischoechinoida with narrow ambulacra, each with only two rows of poriferous plates.

Genus LEPIDOCENTRUS, *J. Müller*, 1856, *Abhandl. d. k. Akad. d. Wiss. Berlin*, p. 258. *L. Schultze*, 1867, *Denks. d. k. Akad. Wiss. Wien*, vol. xxvi. p. 123. *Lovén*, 1874, *Etudes*, p. 39. *Zittel*, 1879, *Palæont.* Bd. i. pt. iii. p. 482. *A. Agassiz*, 1881, '*Challenger*' *Report*, p. 79. (*Amended.*)

Syn. *Palæocidaris*, Beyr.

Interradial areas with from five to nine vertical rows of plates at the ambitus; plates hexagonal, except close to the ambulacra, where they are quadrangular; imbrication aboral and also laterally from the median row; some projection at and over the interradio-ambulacral sutures.

Ambulacra very narrow, two vertical rows of plates, low and broad, each with a pair of pores. Beyond the peristomial margin the plates are continued to the true mouth, no distinction being possible between coronal and peristomial plates. Tubercles of the interradia distant, there being two or three upon a plate near the ambulacra; the other plates carry only one or two. Spines subulate and small, but articulated upon tubercles. Jaws exist.

Fossil. Devonian: Europe. Lower Carboniferous: U. States.

Genus KONINCKOCIDARIS, *Dollo & Buisseret*, 1888, *Compt. Rend. de l'Acad. des Sci. Nat.*, 26 *Mars.*

Shape, apical disk, and jaws unknown.

Ambulacra broad, with two vertical rows of imbricating plates; a pair of pores to a plate near the interradial edge; the pores of the pair oblique, the adoral internal and separated from the other by an oblique ridge; interporiferous area projecting, carrying numerous secondary tubercles similar to those of the interradial plates.

Interradia with seven vertical rows of polygonal plates at the ambitus, the median row the smallest; plates only twice as high as those of the ambulacra, imbricating, carrying rather distant secondary tubercles; the adambulacral plates carry a larger primary, perforated tubercle near their margin. Spines, some stouter than the others and doubtless belonging to the larger tubercles; some very delicate and slender, striated longitudinally and more or less cylindrical.

Fossil. Carboniferous Limestone: Europe (Belgium).

Genus PERISCHODOMUS, *McCoy*, 1849, *Ann. & Mag. Nat. Hist.* ser. 2, vol. iii. p. 251. *W. Keeping*, 1875, *Quart. Journ. Geol. Soc.* 1876, vol. xxxii. p. 35, pl. iii. figs. 1-5. *Worthen & Miller*, 1883, *Geol. & Pal. Illinois*, vol. vii. p. 333. (*Amended.*)

Syn. *Perischocidaris*, Neum.

Test spheroidal, depressed, subpentagonal in outline.

Apical system central, with five broadly pentagonal basal plates surrounding a small periproct, each with from 6-8 genital perforations; radial plates small; anal plates exist.

Ambulacra narrow, straight, sunken, overlapped on either side by the interradia; plates in two vertical series, numerous, small, low, broad, and either regular in shape, elongate pentagonal, or wedge-shaped, the small end of one plate in contact with the large part of its neighbour; plates overlap from the apex actinally, each with a pair of pores in simple vertical series or slightly alternating; surface minutely granular.

Interradia broad, with five vertical rows of large scale-like plates at the ambitus, diminishing in number to two or three at the apex. Plates variable in thickness, thick or thin, convex and irregular in outline, those of the middle rows the most symmetrical, trapezoidal or depressed hexagonal; plates of the middle row overlap those of the row on either side and these the other rows to the ambulacra; each plate also overlaps, with its aboral edge, the plate situated apically to it; the highest plates overlap the basal plates of the apical system.

Ornamentation granular, homogeneous, and of small and also a few large, perforate, non-crenulate tubercles with a low, depressed, broad, conical boss, placed upon a circular scrobicule. A larger tubercle upon some interradial plates close to, or in the second row from the ambulacra, or more than one, often with a circle of the smaller kind near the edge of a plate. Jaws large; teeth large and grooved. Spines, some small, aciculate, and striated; others larger but still short, smooth and cylindrical, tapering, broadest inferiorly, without a ring or collar, striated.

Fossil. Carboniferous: Wexford, Ireland, and Clitheroe, England; Scotland; Europe.

(The diagram given by Keeping, *op. cit.* fig. 3, should be reversed.)

The type specimen of *P. biserialis*, McCoy, in the Woodwardian Museum, Cambridge, has a great adoral underlap of the interradial plates.

Genus Archæocidaris, *McCoy*, 1844, *Synop. Carb. Foss. Irel.* p. 173. *Trautschold*, 1868, *Bull. Moscou*, vol. xli. p. 467. *J. Young*, 1873, *Geol. Mag.* vol. x. p. 302; *Proc. Nat. Hist. Soc. Glasg.* vol. ii. pt. 2, p. 325. *R. Etheridge, Junr.*, 1874, *Quart. Journ. Geol. Soc.* vol. xxx. p. 311. *Lovén*, 1874, *Études*, p. 43. *W. Keeping*, 1875, *Quart. Journ. Geol. Soc.* vol. xxxii. p. 39. *A. Agassiz*, 1881, '*Challenger*' *Report*, p. 77. (*With additions.*)

Syn. *Echinocrinus*, Ag.; *Palæocidaris*, Desor.

Test large. Shape and apical system unknown.

Ambulacra narrow, straight, reaching beyond the peristome to the true mouth; plates irregular, imbricating adorally, each perforated by two pores; plates in two vertical rows.

Interradia with from three to five vertical rows of large, thin plates, the median hexagonal and those of the rows nearest the ambulacra more or less pentagonal, diminishing in number towards the poles, and continued beyond the peristome as small plates. The median plates are bevelled over those on either side slightly, and these over others to the ambulacral edge, which may be raised; the adoral edge of each plate with a broad groove for the reception of the corresponding aboral process of the next plate situated adorally; the plates within the peristome overlap towards the apex. Slits at the peristome for the external branchiæ.

Jaws with long, broad, grooved teeth, the pyramids rather short, upper foramen small, cheeks deeply cut.

A large primary tubercle upon each interradial plate, having a low, conical truncated boss, supporting a narrower subconical perforated mamelon, surrounded by a wide groove; scrobicule large, almost flat; plate beyond with a circlet of secondary tubercles and large granules, with concentric striations or crenulations. Spines of the large tubercles large, long, slender, bluntly serrated on the longitudinal ribs, some spines smooth, and beyond the lower third striated and with rows of oblique spinules. The annular ridge of a spine may be crenulated.

Fossil. Carboniferous Limestone: Ireland, Scotland, England, Wales, Europe, and N. America (Upper Coal-measures, Illinois). Permian: England.

Genus LEPIDOCIDARIS, *Meek & Worthen*, 1869, *Proc. Acad. Nat. Sci. Philad.* p. 79; 1873, *Geol. Illinois*, vol. v. p. 478, pl. ix. fig. 15.

Syn. *Eocidaris*, sensu, Meek & Worthen.

A fragment of a very large test, spheroidal, depressed. Ambulacra narrow, slightly convex; plates in two vertical rows feebly imbricated adorally, compound; the primaries alternate with demi-plates, which are pointed towards the median suture.

Interradia very broad, with eight or nine vertical rows of plates or even more, hexagonal towards the median line and pentagonal close to the ambulacra, all imbricated aborally and laterally; but the lateral overlap is from the ambulacral edge to the central plates, which are overlapped on either side. A large central tubercle on each interradial plate, with a small, perforated, central projection for the spine; the base of the tubercle surrounded by a circular smooth depression, bordered with granular mamelons. Primary spines long, cylindrical, slender, finely striated; articular end perforated and swollen so as to form a distinct ring. Dental apparatus with the teeth grooved.

Fossil. Lower Carboniferous Limestone: N. America.

Genus LEPIDECHINUS, *Hall*, 1861, *Descr. new sp. Crinoidea, Prelim. note, Albany*, p. 18; 1867, *Twentieth Report State Cabinet New York*, p. 295. *Meek & Worthen*, 1866, *Geol. Surv. (Pal.) Illinois*, vol. ii. p. 294 (*reference to Hall*). *Meek & Worthen*, 1868, *Geol. Illinois*, vol. iii. p. 522 (note). *Lovén*, 1874, *Études*, p. 44. *R. Etheridge, Junr.*, 1874, *Quart. Journ. Geol. Soc.* vol. xxx. p. 312. *Keeping*, 1875, *Quart. Journ. Geol. Soc.* 1876, vol. xxxii. p. 36.

Test large, spheroidal.

Apical system pentagonal, made up of several ornamented plates, also a circle of small plates within the periproctal ring.

Ambulacra narrow, straight, with two vertical rows of small, low, broad plates imbricating, the adoral edge of one plate overlapping the aboral edge of the plate below it. A pair of pores to each plate.

Interradia very broad, composed of from nine to eleven vertical rows of plates, diminishing considerably in number apically, the plates nearest the ambulacra smallest; the plates imbricating laterally from the median series and from pole to pole, the

median plate overlapping at its sides its neighbours, and the aboral edge of each plate overlapping the adoral edge of the plate above. Tubercles on each of the plates of the numerous rows above the ambitus, and absent below, except upon the plates nearest the ambulacra, where they are solitary. Dental apparatus unknown.

Fossil. Upper Devonian and Lower Carboniferous: N. America. Carboniferous: Europe (Belgium).

Genus PALÆECHINUS, Scouler, MSS. 1839. *McCoy*, 1844, *Synop. Carb. Foss. Ireland*, p. 171 (pars). *Baily*, 1864, *Journ. Roy. Geol. Soc. Irel.* vol. i. pp. 63–65; 1865, *Geol. Mag.* vol. ii. p. 42. *Meek & Worthen*, 1866, *Pal. Illinois*, vol. ii. p. 229. *De Koninck*, 1869, *Bull. Acad. Brux.* vol. xxviii. p. 554. *R. Etheridge, Junr.*, 1874, *Quart. Journ. Geol. Soc.* vol. xxx. p. 311, pl. xx. *Lovén*, 1874, *Études*, p. 40. *W. Keeping*, 1875, *Quart. Journ. Geol. Soc.* vol. xxxii. (1876), p. 37. *Duncan*, 1889, *Ann. & Mag. Nat. Hist.* ser. 6, vol. iii. p. 196. (*Amended.*)

Syn. *Protoechinus*, Aust.; *Typhlechinus*, Neum.

Test moderate to very large, prolate or oblate spheroidal, rigid, thick.

Apical system central, with a pentagonal periproct surrounded by five large basal plates, each perforated by three canals, or one plate may have but one perforation; five small, doubly perforated radial plates, placed either within the periproctal ring or not separating the basal plates; the anal membrane with concentric plates, largest externally.

Ambulacra narrow, straight, convex along the median line and sunken in the poriferous zones, composed of two vertical rows of very numerous low, thick plates of different shapes; these are either primaries, all of which reach the ambulacro-interradial suture as well as the median ambulacral suture, or alternate plates which are more or less blocked out from the interradial suture, by the increased dimensions of the outer parts of the plates above and below; or there may be demi-plates and more or less perfect primaries in the same ambulacrum, the demi-plates being large at the interradial suture and short and pointed towards the median ambulacral line, the primaries being long and may not reach the interradial suture; compound plates rare. Pairs of pores, in two vertical rows, on each side of an ambu-

lacrum; the outer pairs either in demi-plates or in primaries, the inner pairs always in primaries, which may, however, be short; the outer row is associated with the plates, which form decided salient angles at the ambulacro-interradial sutures; pores of pairs separated by distinct septa and without peripodia, always distant from sutures. Ornamentation of ambulacra of small granules and one or more transverse rows of a few very small tubercles consisting of a flat scrobicule and a small boss.

Interradia broad, convex, with from five to eight vertical rows of thick tumid plates diminishing in number towards the poles; middle plates hexagonal, the adambulacral pentagonal and with the ambulacral edge with salient and reentering angles to fit the corresponding structures of the ambulacral plates; some obliquity of the edges of all the plates, but no true overlap. Ornamentation of numerous small, close tubercles with a flat scrobicule and a boss; there may be a linear ornamentation also; spines small, acicular, short. Jaws and teeth with a groove.

Fossil. Upper Silurian: England. Carboniferous Limestone: England, Ireland, Scotland, Europe; N. America.

The reasons for restricting the species of *Palæechinus* to those with two vertical rows of pairs of pores on each side of an ambulacrum and for insisting upon the presence of radial plates have been considered in a late publication (Ann. & Mag. Nat. Hist. ser. 6, vol. iii. p. 196, 1889), and the necessity for enlarging the interesting genus *Rhoechinus*, W. Keeping, has been shown in the same place. The genus *Rhoechinus* now admits the forms of Palæechini with only a single vertical row of pairs of pores on each side of an ambulacrum, such as *P. elegans*, McCoy.

Genus RHOECHINUS, *W. Keeping*, 1875, *Quart. Journ. Geol. Soc.* vol. xxxii. (for 1876), p. 37. *Duncan*, 1889, *Ann. & Mag. Nat. Hist.* ser. 6, vol. iii. p. 205. (*Amended.*)

Test small or moderate, spheroidal.

Apical system with five basal plates with several perforations; radial plates with more than one perforation; periproctal ring formed by both radial and basal plates or only by the basal plates.

Ambulacra narrow, straight, composed of a vertical row of plates on either side of the median line; plates low, broad, thick, primaries only; a vertical row of pairs of pores on each side of an ambulacrum, a pair to each plate.

Interradia with from four to five rows of plates diminishing at

the poles, irregular in shape or hexagonal in the median line and polygonal at the ambulacral edge. Ornamentation of small granules with occasional small bosses surrounded by a flat scrobicule; plates obliquely bevelled at the edges, admitting of slight overlap.

Fossil. Carboniferous Limestone: England and Ireland.

Family MELONITIDÆ.

Perischoechinoida with broad ambulacra composed of many vertical rows of poriferous plates.

Genus MELONITES, *Norwood & Owen*, 1846, *Amer. Journ.* 2 ser. vol. ii. p. 225. *Meek & Worthen*, 1866, *Pal. Illinois*, vol. ii. p. 227. *Quenstedt*, 1872–75, *Petr. Deutsch.* Abth. i. vol. iii. p. 381, pl. lxxv. figs. 44–50. *Lovén, Études*, 1874, p. 41. *R. Etheridge, Junr.*, 1874, *Quart. Journ. Geol. Soc.* vol. xxx. p. 313. *W. Keeping*, 1876, *Quart. Journ. Geol. Soc.* vol. xxxii. p. 395.

Syn. *Melechinus*, Quenst.

Test very large, ellipsoidal, grooved longitudinally; plates thick.

Apical system central, with five equal, pentagonal, tall basal plates with a corresponding number of intervening radial plates; genital perforations of the basal plates varying in number from three to five, a single pore to a radial plate. Periproct circular.

Ambulacra broad, concave on both sides of a median ridge, with ten or more vertical rows of rather geometrical or of small, low, broad plates, thin or thick, each perforated near its centre by a pair of pores, median rows the largest; some slight imbrication of the plates.

Interradia with seven or eight or nine vertical rows of plates, diminishing in number towards the poles, thick, small, hexagonal near the median lines, pentagonal next to the ambulacra and the edges festooned there for the zigzag of the ambulacral suture. Some obliquity of the edges of the plates, especially when thick. Ornamentation of very small, distant, mamillate, imperforate tubercles; on the ambulacra they are close, and upon scrobicular circles. Spines minute, acicular.

Peristome central. Jaws large, and with stout pyramids, teeth large, grooved, and long, pointed.

The obliquity of the edges of the interradial plates is slight, and its direction and amount are insufficient for imbrication; the ambulacral plates, when thin, have some imbrication adorally and laterally.

Fossil. Carboniferous: England, Europe; N. America.

Genus OLIGOPORUS, *Meek & Worthen*, 1860, *Proc. Acad. Nat. Sci. Philad.* vol. xii. p. 474; 1866, *Pal. Illinois*, vol. ii. p. 247.

Test with the same general shape as *Melonites*, and the apical system also.

Ambulacra with four vertical rows of plates, each plate perforated by a pair of pores, some demi-plates amongst the primaries.

Interradia large, convex, with from five to nine vertical rows of plates at the ambitus, diminishing in number towards the poles.

Fossil. Lower Carboniferous: N. America.

Genus LEPIDESTHES, *Meek & Worthen*, *Pal. Illinois*, vol. iii. p. 522.

Test ellipsoidal?

Ambulacra very broad, consisting of ten vertical series of plates at the ambitus; the plates overlap adorally, and they are broad, small, low, and each has a pair of pores.

Interradia comparatively narrow, with five or six vertical rows of plates, which overlap aborally and at the sides. Tubercles very small, equal.

Fossil. Carboniferous: N. America.

The next genus requires careful consideration, for it was founded partly by Worthen, whose name is so familiar to students of the Palæechinoidea, and yet contains characters which appear to be due to the same cause which led some excellent observers into error with regard to the nature of the imbrication of the Echinothuridæ.

It appears that it is quite possible that the distinguished American palæontologist may have seen the plates of his type from within, and, if so, it accounts for the character which he has given the type, of the plates overlapping in a direction contrary to all other Palæechinoidea. Worthen and Miller, after noticing

this anomaly, observe that the direction of the overlap is the same as that seen in Echinothuridæ. Now there is no doubt that this mistake about the direction of the overlap of the ambulacral and interradial plates in Echinothuridæ originated with the late Sir Wyville Thomson, who wrote in 'The Depths of the Sea,' 1873, p. 158, that the overlap was of "the plates of the interambulacral areæ from the apical pole towards the mouth, those of the ambulacral areæ from the mouth towards the apical disk." He referred, for the purpose of illustration, to his figure 28 (on p. 157). Unfortunately this figure is of part of the *inside* of the test of *Calveria* (*Asthenosoma*) *hystrix*, Wy. Th. The direction of overlap is always considered in relation to the outside of tests. In 1874 Mr. R. Etheridge, Junr. (Quart. Journ. Geol. Soc. vol. xxx. p. 307), quoted Sir Wyville Thomson's words, and it became generally believed that the overlap of the plates of the Echinothuridæ was in the opposite direction to that of the Perischoechinoidea. But Sir Wyville Thomson also wrote in 1874 (Phil. Trans. Roy. Soc. p. 730), after the publication of Mr. Etheridge's paper, as follows:—"The plates of the interambulacral areas overlap from the mouth towards the apex, and the ambulacral plates in the opposite direction." A. Agassiz also pointed out that the overlap is normal. Again, the most striking character of Worthen and Miller's genus is the projection in the form of humps of the ambulacra near the apex. But that condition is so anomalous that one is tempted, especially after the explanation of the abnormal overlap, to believe that the reverse condition should be seen from outside, and that the humps are really marsupia seen from within the test. The genus as defined by its authors is given, but the remarks just made should have their weight.

Genus Hybochinus, *Worthen & Miller*, 1883, *Geol. & Pal. of Illinois*, vol. vii. p. 331.

Test flexible, subspheroidal, consisting of 5 ambulacral and the same number of interradial areas; protuberances at the apical ends of the ambulacra (*possibly marsupial cavities*).

Ambulacra composed of numerous (10) ranges of alternating and overlapping plates, and even more at the ambitus; each plate perforated in the central part by a single pair of pores. The plates imbricate from below upwards (*probably from above downwards*).

Interradia one half as broad as the ambulacra, with five or more vertical rows of overlapping plates, which diminish in number towards the poles; the plates imbricate from above downwards (*probably the reverse*) and from the central range outward.

Surface covered with small granules for the articulation of minute spines. Jaws consisting of large subtriangular, truncated, conical pieces deeply furrowed towards the ends and perforated in the central part. Genital plates probably with four pores. The spines minute and acicular.

Fossil. Carboniferous: N. America.

Genus PHOLIDOCIDARIS, *Meek & Worthen*, 1869, *Proc. Acad. Sci. Philad.* p. 78 (*under* Lepidocentrus); 1873, *Geol. Illinois (Palæont.)*, vol. v. p. 510, pl. xv. fig. 9. *Lovén*, *Études*, 1874, p. 40. *Zittel*, 1879, *Palæont.* Bd. i. p. 482.

Fragments belonging to individuals of from 90 to 100 millimetres in diameter.

Interradia with five or more rows of plates imbricated aborally and laterally, granular, thin, rounded, convex, unequal, those nearest the ambulacra three or four times the size of the others, elliptical, higher than broad, projecting. On one surface (ventral?) there are primary tubercles one to a plate, placed centrally, and perforated, and surrounded by two smooth rings; similar tubercles on the opposite surface of the test only on the ambulacral plates. Spines subulate, finely striated longitudinally.

Ambulacra broad, with six vertical rows of small plates, variably shaped, oval, rhomboidal, or with the angles rounded; plates imbricating adorally; with a moderate-sized mamelon, and the pores in single or sometimes double pairs, in a depression.

There are also small spines and small buccal scales present.

Fossil. Inferior Carboniferous: N. America. Type *P. irregularis*, Meek and Worthen.

There is a singular question about the zoological position of *Palæodiscus*, Salter, for the late Sir Wyville Thomson placed it as a synonym of *Echinocystites*. There are specimens in the Museum of Practical Geology, Jermyn St., and in the British Museum; and it is tolerably evident that there are forms there which simulate the typical *Palæodiscus*, which Salter decided to be an Asteroid. Two of these forms in the British Museum are associated, and properly so, with the Palæechinoidea, but are flattened, badly preserved semicasts. The interradial parts have

several vertical rows of plates and the ambulacra are narrow, and with a multitude of small, low plates each perforated minutely by a pair of pores; as there are two pairs of pores on each side of the median line and placed nearly horizontally, the presence of two vertical rows of ambulacral plates on either side of the median line must be admitted. The peristome presents some appearance of jaws. There is not enough to define a new genus from, and certainly the reason for placing the forms in *Echinocystites* is not apparent. The alliance is with *Oligoporus*, but it is necessary to wait for better specimens. (See *Echinocystites*.)

Order III. PLESIOCIDAROIDA.

Test small, subhemispherical, solid, with a large apical system, having large united basal plates and a central periproct. Ambulacra narrow, and with two vertical rows of poriferous plates. Interradia with a single peristomial plate, followed by three plates separated by vertical sutures. Large tubercles on the actinal surface.

Genus Tiarechinus, *Neumayr*, 1881, *Sitzungsb. d. kais. Akad. d. Wiss. Wien*, 1882, Bd. 84, Heft i. p. 69. *Lovén*, *Pourtalesia*, 1883, *Kongl. Svenska Vetensk.-Akad. Handl.* Bd. xix. pp. 11, 64, pl. xiii.

Test small, flat actinally and slightly elliptical in marginal outline, subhemispherical dorsally.

Apical system very large, extending nearly halfway to the ambitus; periproctal space small, pentagonal; basals very large, the posterior the smallest, hexagonal, forming a very broad ring; genital pores two in number, one in the basals 1 and 3; radial plates pentagonal, notching the union of the basals slightly; pores absent.

Ambulacra band-like, equal, but the posterior pair are closer together than the others; straight, broadest at the peristome, made up of two vertical rows of numerous low, broad primary plates, each with a pair of pores and a small plain tubercle.

Interradia broad, actinally composed of a single peristomial plate, above which are three tall plates only, one median and the others at its sides. Ornamentation, a plain primary tubercle to each plate at the ambitus and actinally; elsewhere the test is coarsely granular, including the apical system. Sutures very

invisible; test solid-looking. Peristome large, oval-elliptical, without branchial incisions.

Fossil. St. Cassian-Trias: Europe.

It is to be observed that the single species of this genus, *T. princeps*, Laube sp., was diagnosed from specimens 3·8 millim. in height, 5·2 millim in length, and 4·9 millim. in breadth.

Order IV. CYSTOCIDAROIDA, *Zittel*, 1876–81.

Test irregular (exocyclic), globular or ovoid, thin, flexible (?); madreporite central and dorsal. Ambulacra narrow, and with two vertical rows of poriferous plates. Interradia broad, with numerous vertical rows of scale-like moveable plates; periproct in the posterior interradium above the ambitus.

There has been a difficulty made about the name of the principal, if not the only, genus of this family. Wyville Thomson defined the genus very well in 1861, and employed the term *Echinocystites*, which was a good one. In 1864 Hall called a genus of Cystidea by the name already occupied by Wy. Thomson's genus. In 1876–80 Zittel, in his 'Palæontologie,' p. 480, altered Wy. Thomson's term to *Cystocidaris*, and noticed the fact about Hall's using the name *Echinocystites*, although it was preoccupied. Certainly Wy. Thomson's name must continue, and Hall's Cystidean will have to be called by something else, and *Cystocidaris* must lapse according to the ordinary rules of nomenclature.

Genus ECHINOCYSTITES, *Wy. Thomson*, 1861, *Edinb. New Phil. Journ.* n. ser. vol. xiii. p. 108, pls. iii., iv. (*non* Echinocystites, *Hall*, 1864).

Syn. *Cystocidaris*, Zitt.; *Palæodiscus*, Salt. in Wy. Thoms. *op. cit.* p. 116*.

Test large, spheroidal or ovoid, thin, flexible.

Apical system central and dorsal, apparently consisting of a large madreporite only.

Ambulacra narrow, straight; plates numerous, small, low, in four vertical rows, a central pair of pores in each plate, and

* The genus *Palæodiscus*, Salter, 1857, Ann. & Mag. Nat. Hist. ser. 2, vol. xx. p. 332, was considered by Wy. Thomson in the same essay as that which contained the description of *Echinocystites*, and the solitary species was stated to be flexible and the teeth were as chisels.

therefore four vertical rows of pores two on each side of a median groove.

Interradia with numerous, 6–8, vertical rows of scale-like lozenge-shaped or irregular plates, each with a small primary tubercle surrounded by a scrobicule; granules present, and the spines short, sharp, striated, and serrate. The areas appear to unite apically.

Peristome central, actinal, small, pentagonal or stellate, surrounded by marginal ambulacral and interradial plates; dense sheaves of short spines at the edge. Jaws highly developed, five pyramids; the inner, oral surface of the pyramids with strong spines* or with striated chisel-shaped teeth. Periproct large, on a low pyramidal protuberance in an interradium, at about one third of the diameter of the test from the peristome.

Fossil. Upper Silurian: Scotland.

II.

Remarks upon the Subclass Euechinoidea, the five Orders, definitions, and of the Suborders of the second Order. Order I., the Cidaroida; the Family Cidaridæ. Section I. Genus Cidaris (note on the classification). The seven divisions of the genus; definitions; Subgenus Goniocidaris. Other genera. Section II. Order II., the Diadematoida. The Suborder Streptosomata; considerations regarding the anatomy and classification. The Family Echinothuridæ, and Subfamilies Pelanechininæ and Echinothurinæ; the description of the genera.

II. Subclass *EUECHINOIDEA.*

The classification of the Euechinoidea, like that of many of the great groups of Invertebrata, can be generally natural and definite; but an artificial method seems to be necessary, occasionally. Some of the " Orders " are well defined by characters of considerable anatomical and physiological value, but others are of unequal relative value, are perhaps too comprehensive, and Suborders have to be founded.

The Orders Cidaroida and Clypeastroida, amongst the Gnathostomes, are well defined, but the discovery of the Drs. Sarasin

* The spines at the oral surface of the pyramids are accidental, and the result of crushing.

regarding the internal branchiæ of the Echinothuridæ and Ludwig's remarks concerning the rudimentary nature of these organs in some Diadematidæ, coupled with the knowledge that in some genera of this great family the internal branchiæ are not seen, renders it impossible to classify upon the old grounds. The difficulty is where to place the Echinothuridæ, and the Temnopleuridæ, Echinometridæ, and Echinidæ in reference to the Diadematidæ and close allies, and the Saleniidæ. It is the opinion of A. Agassiz that the Echinothuridæ should be placed close to the Diadematidæ and not with the Palæechinoidæa; and it appears to be justified by facts. But the flexible forms with the ambulacral plates continued to the mouth are, as a group, not of the same taxonomic value, in reference to the Diadematidæ, as the other families just mentioned. The Echinothuridæ have subordinal characters. On the other hand, it is not possible to separate the Echinidæ, Echinometridæ, and Temnopleuridæ from the Diadematidæ; and they all belong to a suborder.

There is at present no other method possible than to separate the Gnathostomes which are endocyclic, and which have continuous perignathic girdles and external branchiæ, into two Suborders. In one the test is flexible and the branchiæ are both external and internal; and in the other the test is rigid, and the internal branchiæ are either small, rudimentary, or absent.

A difficulty occurs amongst the Exocyclic genera, and there is, at present, no satisfactory classification possible of some of the Exocyclica without teeth.

It appears to be straining a point to separate such a genus as *Discoidea* from the Order which contains *Holectypus*, but the perignathic girdle of the last-named and its jaws and teeth differ from those of the first-named genus. In *Discoidea* there is a perignathic collar with possibly the relics of ambulacral processes; but it is the opinion of Mr. Percy Sladen and the author of this Revision that no jaws were present. Lovén is of a different opinion, but still no jaws have been found. It is not possible to place *Echinoconus* with either of these genera, for the ambulacra and the peristome differ, it has most rudimentary auricles, and the perignathic girdle is reduced to more or less defined interradial ridges, and the genus was jawless. *Discoidea* was a transition form, between the Gnathostomes and the Suborder of Cassiduloidea, and part of the dental apparatus was abolished, and degeneration of the perignathic girdle occurred. To place

the genus in a separate Suborder is not advisable; and it is perhaps best to enlarge the definition of the Order, which contains *Holectypus* as a type, so as also to include the genera with perignathic girdles of more or less continuous collar-shape, without jaws. At present our knowledge of the genera *Galeropygus* and *Pachyclypeus* is so defective that they must remain *incertæ sedis*.

The abolition of the toothless Irregulares (Exocyclica) as a group assists the definition of the Cassiduloidea, for *Phyllo-clypeus*, *Conolampas*, and even *Echinoconus* can enter it, only the latter genus being, possibly, somewhat artificially placed. The separation, made many years since by Desor, between the Cassiduloids with a floscelle and without that important peristomial character, holds good, and the only difficulty in the taxonomy is to place the few genera which have, besides some Cassiduloid characters, the dissimilarity of the ambulacra characteristic of the Spatangoida, and variable apical systems, such as *Eolampas*, *Archiacia*, *Claviaster*, *Asterostoma*, &c. These genera are aberrant, yet they link the Cassiduloidea with the Spatangoidea in an Order. They form a new Family, the Plesiospatangidæ.

The classification of the great group of Spatangoidea—a Suborder—has been rendered difficult in consequence of the discovery of the abyssal forms. Under the hands of Lovén* and A. Agassiz† the suborder has become manageable, and its Families are those of the Ananchytidæ, Spatangidæ, Leskiidæ, and Pourtalesiidæ. The Spatangidæ contain four well-marked types, but they do not appear to be worthy of subfamily distinction, for their separating characters are rather artificial and are of unequal value. The divisions are those insisted upon by Lovén, namely, the genera without fascioles, those without a subanal fasciole, those with a subanal fasciole, and those which are apetaloid. These are the divisions of Adetes, Prymnadetes, Prymnodesmia, and Apetala.

The attempt is made, in this revision, not to overvalue the characters of perforation and crenulation or of the plain and imperforate nature of primary tubercles. The physiological value of crenulation is very slight, it often occurs or is absent in the

* 'Études' and 'Pourtalesia.'

† Report on the 'Challenger' Echini.

same species and specimen, and it and the opposite condition will not distinguish genera for the future *.

The nature of the ambulacral plates, the arrangement of the pairs of pores, and the shape and functions of the tentacles are, however, considered to be of great taxonomic importance. The great importance of the radial plates, formerly erroneously considered to have a reference to an optic organ instead of a primary tentacle, is not admitted; and M. Pomel is not followed when he endeavours to establish genera and subgenera upon the entrance or not of one or more of the radial plates within the periproctal ring. Following A. Agassiz, the structure and shape of the spines are considered of secondary importance in classification, and genera are not separated on account of dissimilarities in the spines, nearly or quite all other structures being the same. These remarks will account for a proceeding which may take some palæontologists by surprise, namely, the absorption of *Pseudodiadema* into the previously diagnosed genus *Diadema*, and the union with this last of many subgenera which were formerly considered to be genera.

II. Subclass *EUECHINOIDEA.*

I. Order.—Euechinoidea with an actinal, central peristome and an abactinal periproct, situated within the dorso-central system; with internal branchiæ only, and having jaws and more or less vertically placed teeth, and a discontinuous perignathic girdle; the interradial as well as ambulacral plates continued beyond the peristome to the true mouth. Spheridia absent. Endocyclic, anectobranchiate, Gnathostomes.

CIDAROIDA.

II. Order.—Euechinoidea with an actinal, central peristome and an abactinal periproct situated within the dorso-central system; with perfect or rudimentary or absent internal branchiæ, with external branchiæ and incisions in the peristome; with jaws and teeth and a continuous perignathic girdle; ambulacral plates alone continued beyond the peristome or as separate buccal plates. Spheridia present. Endocyclic, ectobranchiate, Gnathostomes.

DIADEMATOIDA.

* Ann. & Mag. Nat. Hist. 1888, pp. 120-122.

1. Suborder STREPTOSOMATA.—Test more or less flexible, with external and internal branchiæ. Ambulacral plates alone continued beyond the peristome to the stoma.

2. Suborder STEREOSOMATA.—Test rigid, with external branchiæ and rudimentary or absent internal branchiæ; with isolated buccal ambulacral plates.

III. Order.—Euechinoidea with an actinal, central peristome, and the periproct situated beyond the dorso-central system in the posterior interradium; with external branchiæ; with a pair of pores or only one pore to an ambulacral plate; with feeble jaws and vertical teeth, or without these structures; with a variably constructed perignathic girdle. Spheridia present. Exocyclic, oligoporous, Ectobranchiata.

HOLECTYPOIDA.

IV. Order.—Euechinoidea with an actinal peristome, a periproct situated beyond the dorso-central system, in the posterior interradium; with external branchiæ; with tentacular pores in the interradia, and more than a pair to an ambulacral plate; tentacles heteropodous in arrangement; with more or less horizontal and rarely vertical teeth, and with jaws situated superiorly to the disconnected perignathic girdle. Spheridia present. Exocyclic, petalobranchiate, polyporous, Gnathostomes.

CLYPEASTROIDA.

V. Order.—Euechinoidea with an actinal or a frontal peristome, and a periproct situated beyond the dorso-central system, in the posterior interradium; without external branchiæ, jaws, teeth, and perignathic girdle. Spheridia present. Exocyclic, anectobranchiate, Nodostomata.

SPATANGOIDA.

1. Suborder CASSIDULOIDEA.
2. Suborder SPATANGOIDEA.

Subclass II. *EUECHINOIDEA.*

Order I. CIDAROIDA (p. 24).

Family CIDARIDÆ, *Agassiz & Desor*, 1846, *Catal. Rais.*, *Ann. Sci. Nat.* vol. vi. p. 325 (pars). *Joh. Müller*, 1854, *Abh. d. k. Akad. d. Wiss. Berlin*, p. 123. *Desor*, 1858, *Synopsis*, p. 2 (pars). *Wyv. Thomson*, 1874, *Phil. Trans.* vol. clxiv. p. 720. *A. Agassiz*, 1874, *Revision*, pp. 251 & 384 (pars)*.

Test spheroidal; the ambulacra narrow, with two vertical rows of very numerous low plates, which are primaries, and rarely become compound, united by their edges, each with a pair of pores arranged in single and rarely in double series; other plates continued from the peristome to the true mouth and imbricating, besides being perforated; interporiferous areas with large and small granules only.

Interradia broad, with few plates in two vertical series, most with a large primary, scrobiculate tubercle, carrying a large spine, secondary tubercles and granules with smaller spines; plates united at their edges; some broad and low plates continued from the peristomial margin to the true mouth, and imbricating.

Apical system large, with five basal plates and five radial plates, each with a perforation; periproct in the midst, covered with plates. A madreporite in the right anterior basal plate.

Jaws with the foramen of the pyramid small, and not closed in by epiphyses; teeth grooved; perignathic girdle discontinuous, with a bifid process on each interradium only. Branchiæ internal; tentacles subheteropodous †. Peristomial branchial incisions and external branchiæ absent. Spines variable. Spheridia absent.

* A. Agassiz pointed out in the 'Revision' that the anatomical researches of Johan. Müller rendered a correct definition of the family Cidaridæ possible. But nearly all the definitions which have been recorded have been too synthetic. Since A. Agassiz gave such a mine of information regarding the recent genus *Cidaris* and its subdivisions, there has been a general movement towards simplification. The old subfamily "*Salenidæ*" has been eliminated and the fossil and recent Cidaridæ form a tolerably homogeneous group. In the Report on the 'Challenger' Echini, 1881, A. Agassiz remarks concerning the branchial slits at the true mouth of recent specimens of *Cidaris* (p. 53):—"Whether it is these organs (gills) which find their way through the cuts or not, in our Florida species, I am unable to state; and a renewed examination of living specimens will be necessary before we can settle this interesting question."

† The definition of terms is given at the end of this Essay.

Order CIDAROIDA.

Family CIDARIDÆ.

Section I. Ambulacral pairs of pores uniserial.

Genus *Cidaris*.
Subgenus *Goniocidaris*.
Genus *Orthocidaris*.
Temnocidaris.
Polycidaris.

Section II. Ambulacral pairs of pores biserial.

Genus *Diplocidaris*.
Tetracidaris.

Section I.

The first genus of the Cidaridæ is *Cidaris*, Agassiz and Desor, 1846; and it is a very large one. Nevertheless it is well differentiated from any other genus; and it would be easily defined had not a series of artificial divisions, raised to the dignity of subgenera and even of genera, been employed to group the species. It is best to give the amended generic definition, and then to consider the grouping of the species.

Genus CIDARIS, Klein, 1734 (pars); Lamarck, 1816 (pars); Gray, 1825 (pars). *Agassiz & Desor*, 1846, *Cat. Rais.*, *Ann. Sci. Nat.* vol. vi. p. 325. *J. Müller*, 1853, *Bau. d. Ech.*, *Abhl. d. k. Akad. d. Wiss. Berlin*, pub. 1854, p. 123. *Desor*, 1858, *Synopsis*, p. 3. *A. Agassiz*, 1872–74, *Revision of the Echini*, p. 252; and 1881, '*Challenger*' *Report*, p. 33. *C. Stewart*, 1871, *Quart. Journ. Micr. Sci.* n. s. vol. xi. p. 54; and 1879, *Trans. Linn. Soc.* vol. i. p. 569. *Lovén*, 1887, *Ech. descr. by Linnæus*, pp. 138, 146.

Syn.:—*Eocidaris*, Desor, 1858 *; *Anaulocidaris*, Zittel, 1884 †; *Discocidaris*, Döderlein, 1885 ‡; *Schleinitzia*, Studer §.

Syn., when employed as genera and not as artificial divisions:—*Stephanocidaris*, A. Agassiz ‖; *Rhabdocidaris*, Desor ¶; *Leio-*

* Synopsis, p. 155.

† N. Jahrb. f. Min. Bd. ii. p. 132.

‡ Archiv f. Naturg. Wiegm. 1885, Heft i. p. 82.

§ Monatsb. d. k. Akad. d. Wiss. Berlin, 1877, p. 463.

‖ Revision, p. 393.

¶ Synopsis, p. 39; and de Loriol, 1883, Cat. Rais. d. Éch. réc. à l'Ile Maurice, p. 7.

cidaris, Desor *; *Phyllacanthus*, Brandt †; *Dorocidaris*, A. Agassiz ‡.

Test variable in size and thickness, spheroidal, depressed or tall.

Apical system large, either flat, and with the large geometrical basal plates weakly united, or solidly sutured; the radial plates large, separating the basals or not, and in the first case often touching the outer periproctal plates which may intrude. Basal pores large; the madreporite in the right anterior basal plate; the periproct pentagonal, variable in size, numerously plated.

Ambulacra narrow, undulating or nearly straight, composed of very numerous broad low primaries, which are perforated by single pairs of pores, the pores being variable in their distance, and may or may not be united by a groove; poriferous zones broad; interporiferous areas with vertical rows of distinct granules which are small, and may have rudimentary mamelons. The plates are continued beyond the peristomial margin to the edge of the mouth, and are low, broad, imbricating, and each is pierced by a pair of pores.

Interradia broad; coronal plates few, from 5 to 11, in each of the two vertical rows, each with a primary tubercle, scrobiculate, and perforate, may be crenulated or not. Scrobicule large, often sunken, its margin with small secondary tubercles and large granules; the space beyond the scrobicules with large miliary granules.

Peristome large, without branchial incisions; the interradial plates continued beyond the peristome to the mouth, small, low, imbricating, in double series. Spheridia absent.

Perignathic girdle discontinuous; auricular processes upon the interradia. Pyramids of jaws unclosed above by epiphyses; teeth grooved.

Spines of the ambulacra, the scrobicular circle, the miliary zones, and of the plates beyond the peristome very similar, small, straight, blade-of-oar-shaped, very close; and those of the scrobicules cling around the primary spines. Primary spines very variable, even in the same species, with a calcareous network internally and solid outside, lamellary, or fluted externally, and variously spinuled, granulate, laminated, some whorled; long, with a cylindrical or angular section, pointed or blunt; or very short,

* Synopsis, p. 48.

† Prodr. d. Act. d. l'Acad. St. Pétersb. 1834 (Additions), p. 267.

‡ Revision, p. 254.

clubbed, and large at the blunt end; fusiform, sharp, or blunt; cylindrical and blunt, with spinules, thorns, and granules or disk-shaped expansions, or cup-shaped at the end, with spines radiating; or long, flat, expanding, furrowed and spined.

Tentacles disciferous actinally, and gradually becoming non-prehensile and branchial. Pedicellariæ large, tridactyle, gemmiform, and small and blunt-headed.

Sexes separate or not; young usually undergoing metamorphoses, rarely not, and then found upon the parent.

Fossil. Permian: Europe. Trias: Europe, Asia *. Jurassic to Post-pliocene: England and Europe, N. Africa, Asia. Cretaceous to Tertiary: N. America, Egypt, and W. Africa. Tertiary: Australia.

Recent. World-wide.

Every writer upon the classification of the Echinoidea since Desor has complained of the unsatisfactory attempts of some of the most distinguished authorities to subdivide the genus *Cidaris*. The subdivisions gradually became subgenera; and of late these have received generic importance. The divisions were made upon very unimportant external characters; and subsequent research has proved that these structures, the variations of which led them to be considered of good diagnostic value, are of no physiological importance†. The presence or absence of perforation and crenulation of the primary tubercles, and the connection of the pores of pairs by a groove, or their disconnection by a granule or swelling, have really been the main features relied upon to establish divisions, subgenera, and finally genera. Common observation will satisfy anybody that crenulation is not invariable upon the same test in many instances; and it is a mistake to believe that it is a structure which relates to the strength of the spine-muscles. These are attached to the edge of the scrobicule, and are inserted just below the milled ring of the spine; and they have nothing to do with the crenulation. This appears to add to the attachment surface of the membrane of connective tissue which closes the ball-and-socket joint of the spine and tubercle.

The grooving, or the reverse condition, between the pores of a pair is of no physiological importance whatever; and it is frequently impossible to decide whether the pores are connected by a groove or not.

Any classification in which these characters are used is artificial.

The number of interradial coronal plates is of physiological importance;

* *Eocidaris* = *Cidaris* has been found in the Salt Range, British India.

† Duncan, 1888, Ann. & Mag. Nat. Hist. vol. i. p. 124.

and there is a great temptation to consider typical Cidarids as having but a few, say not more than seven, in a vertical row.

But all the other structures, or the varieties of structures, are to be noticed in combination with few or many plates. The spines of some species are apparently so peculiar that they have been used as classificatory data of primary importance; and one subgenus has been founded upon them. But A. Agassiz very properly now lays down the law that Cidarids cannot be classified by their spines alone. The nature of the apical disk is very different in some Cretaceous and recent species: in the former it is solid, and with a tall basal ring and a small pentagonal periproct in some well-known forms; and in the latter it is large, flat, with feebly united plates, the radial plates sometimes separating (with or without the assistance of some periproctal plates) the basals. But there is every link in the intermediate chain of structures to be seen, and even in the same species there are variations in relation in the position of the basals and radials, entry or not of the latter taking place within the ring. The size of the miliaries and the occasional want of perfection of the tubercles of the interradial plates close to the apex cannot be of any great importance.

Both Lamarck and Agassiz, and subsequently Desor, insisted upon the subdivision of *Cidaris*, in reference to the condition of the primary tubercles and the grooved or not nature of the test between the pores of pairs. Desor thus established *Rhabdocidaris* and *Leiocidaris*; Brandt established the subgenus *Phyllacanthus* from the nature of the spines and straightness of the ambulacra. A. Agassiz decides against *Leiocidaris*, and adds to the diagnosis of *Phyllacanthus*; and he introduces *Dorocidaris*, which is a true *Cidaris* with non-crenulate tubercles. De Loriol and M. Cotteau have both altered the range of diagnosis in *Rhabdocidaris* and *Leiocidaris*; and the first-named naturalist decides against *Leiocidaris* and *Phyllacanthus*.

It appears, after having given the subject careful consideration, that none of these divisions is worthy of a true subgeneric position, but that *Rhabdocidaris*, *Leiocidaris*, *Dorocidaris*, *Stephanocidaris*, *Phyllacanthus* (Brandt), A. Ag., and *Porocidaris* are fairly useful artificial divisions. They are synonyms of *Cidaris*, however. *Goniocidaris* is a good subgenus.

I. Division. Typical *Cidaris*.

If the system of subdividing the genus artificially is adopted, the typical species will be those with a small number of interradial coronal plates (5–8), and with the ambulacra more or less undulating, the pores of pairs rather close and separated by a nodule or ridge, and the primary tubercles perforated and crenulated.

The other divisions will be as follows:—

II. Division. Syn. Genus *Rhabdocidaris*, Desor, 1848, Synopsis, p. 39.

Large swollen tests, often as high as broad; remarkable on account of the particular structure of the poriferous zones, which are broader than in true *Cidaris*, the two pores of a pair being distant, and linked by a groove which is small and horizontal. Ambulacra in general straight or slightly flexuous. Tubercles large, always strongly crenulated (at least in the fossil species), and proportionally more numerous than in true *Cidaris*. Scrobicules large, often elliptical. Miliary zone broad. Spines very stout, some cylindrical or prismatic, and furnished with dentations or spines, and others in the shape of oars, either simple or with spines at the base. Articular facette very large and strongly crenulated. Neck little or not constricted.—(Type, *Cidaris copeoides*, Cott., and *C. guttata*, Cott.)

III. Division. Syn. Genus *Leiocidaris*, Desor, *op. cit.* p. 48.

Large tests, with smooth tubercles; but they differ from *Cidaris* because the pores of a pair are linked by a small groove, as in *Rhabdocidaris*. Miliary zones very broad. Spines as large smooth cylinders, resembling those of *Heterocentrotus*. Desor defines *Leiocidaris* as *Rhabdocidaris* with uncrenulated tubercles.—(*Cidaris canaliculata*, Dunc. & Sladen, Foss. Ech. Sind, Pal. Ind. ser. xiv. p. 109, 1884, is a good type.)

IV. Division. Syn. Subgenus *Dorocidaris*, A. Agassiz, 1872, Revision, p. 254.

Ambulacral median area narrow; a small number of interradial plates; scrobicules sunken, and median space also. Tubercles without crenulations, and the pores of a pair without an intermediate groove. It will be observed that the spines are very variable in this division.

Dorocidaris is a true *Cidaris*, with no crenulation on the tubercles.—(*Cidaris papillata*, Leske, is the type.)

V. Division. Syn. Genus *Stephanocidaris*, A. Agassiz, 1872, Revision, p. 393.

Test thin. Apical system larger than the peristome, the plates feebly united, and the whole flexible; the polygonal basal plates separated by large radial plates.—(*Cidaris bispinosa*, Lmk., is the type.)

VI. Division. Syn. Subgenus *Phyllacanthus*, Brandt, 1834, Rec. d. Actes de l'Acad. Imp. d. Sci. de St. Pétersb., pub. 1835, Additions, p. 267; A. Agassiz, Revision, 1873, p. 387. (*Amended.*)

Test large, swollen, comparatively thin, and with the maximum of coronal plates, 8–11. Apical system large; the basal plates in contact, or separated by radial and anal plates. Ambulacra almost straight or very slightly undulating, broad; the pores in a broad zone, and united by a groove. Primary tubercles of the interradia large, perforate, non-crenulated, scrobicular circle large, areola sunken, mamelon small. Miliary area wide. Spines mostly solid, the primaries varying greatly in shape and size, cylindrical, triangular, flattened in section, elongate or club-shaped, blunt or pointed; flutings strong, either as simple striation, or as continuous or broken lamellæ variously projecting, sometimes forming secondary spinules.—(*P. dubia*, Brandt. See Lovén's remarks upon the subgenus in 'Echin. described by Linnæus,' 1887, p. 148.)

VII. Division. Syn. Genus *Porocidaris*, Desor, Synopsis, pp. 46, 47. Wy. Thomson, 1874, Phil. Trans. p. 726.

Ambulacra broad and straight; pores wide apart, united by a groove. Primary interradial tubercles with small perforate and crenulated mamelons; the scrobicules more or less transversely oval, with shallow grooves more or less defined, radiating from the periphery towards the centre, along the flank of the tubercles, with or without pores or depressions at the outer extremity of the grooves. Some spines flattened, with strongly serrated edges, resembling the smaller peristomial spines of *Cidaris papillata*.—(*Cidaris purpurata*, Wyv. Thoms., the type.)

Subgenus Goniocidaris (genus), *Desor*, 1846, *Agassiz & Desor*, *Cat. Rais. d'Éch.*, *Ann. d. Sci. Nat.* vol. vi. p. 337. *Lütken*, 1864, *Ved. Med. f. Nat. Kjöbenh.* p. 137. *A. Agassiz*, 1873, *Revision*, p. 395.

Test high; coronal plates numerous; ambulacra narrow; the median sutural regions of interradia and ambulacra sunken, forming with the horizontal sutures a zigzag, culminating in pit-like depressions at the angles of junction of the sutures.

Spines variable, either long, cylindrical, and pointed, the surface having thorns, pointing irregularly outwards, or short, stout, cylindrical or flat in outline, with enlarged cup-like tops with a fringe of strong radiating spinules; spinules in vertical series along the stems or restricted to the edge, in the flat specimens.

Viviparous, unisexual.

Fossil. Tertiary: Sind, Asia.

Recent. Philippines; Indian Archipelago; East Indies; Australia, N. South Wales; Tasmania; Falkland, Marion, and Kerguelen Islands; Patagonia; Antarctic Ocean; Natal; Zanzibar.

Wy. Thomson and Studer discovered about the same time, in 1876, that *Goniocidaris* was viviparous, and that the young were carried upon the apical system, protected by the upper spines of the test, until their full development took place. Studer, 1876, Berl. Akad. Monatsb. p. 455, noticed the large genital openings covered by a thin membrane; and Thomson described the method of carrying the young, and that the female genital openings notch the edge of the basal plates (Journ. Linn. Soc. vol. xiii. 1876; and Voyage of the 'Challenger,' vol. ii. p. 228). It is necessary to admit the unisexual nature of the species*.

Genus ORTHOCIDARIS, *Cotteau*, 1862, *Pal. Franç., Terr. Crét.* vol. vii. p. 364.

Syn. *Hypodiadema*, Desor (pars).

Test moderate and subspherical.

Apical system flush, pentagonal, small.

Ambulacra narrow, straight; interporiferous area with small granules, which may have mamelons, placed in several rows and without order; pairs of pores in simple straight series, the pores separated by a granule, in low primary plates.

Interradia very broad, plates numerous; primary tubercles very small, perforate and plain, distant, occupying a small portion of their plates; the scrobicules small and circular; the miliary areas large, and the granules with mamelons.

Peristome small, narrow, without branchial incisions; the interradial lips the largest.

Fossil. Lower Cretaceous: Europe.

* Genus *Discocidaris*, Döderlein, from Japan, has large outer anal plates and disciform ends to the primary spines; and it is a *Cidaris*. *Anaulocidaris*, Zittel, is too close to *Cidaris* to be considered otherwise than a species.

Schleinitzia, Studer, is a *Cidaris*.

Eocidaris, Keyserl., now appears to have all the requisite structures to classify it with *Cidaris*, and thus the genus is carried back in time to the Permian age.

The next three genera are not satisfactory.

Genus TEMNOCIDARIS, *Cotteau*, 1863, *Pal. Franç., Terr. Crét.* vol. vii. p. 355.

Test large, spheroidal.

Apical system large, flush, wider than the peristome.

Ambulacra subflexuous, narrow; poriferous zones broad, the pairs of pores in simple series; interporiferous areas with small granules placed without order, except a larger row near the poriferous zone.

Interradia large; tubercles numerous and large, plain and scrobiculate; miliary areas large and minutely granular, marked with linear depressions.

Peristome moderate, subcircular. Numerous small shallow circular pits in the miliary areas and in the interporiferous areas, but scattered without order, and not in relation with the sutures or their angles of junction.

Fossil. Cretaceous: Europe.

The pits do not resemble those of the Temnopleuridæ; and there is a suspicion of their *post-mortem* origin. Certainly the test, apart from the pits, is that of a *Cidaris*.

Genus POLYCIDARIS, *Quenstedt*, 1858, *Der Jura*, p. 644, tab. 79. fig. 69; 1874, *Petr. Deutschl.* p. 216, tab. 69. figs. 10–12. *Zittel*, 1879, *Palæont.* Bd. i. Lief. iii. p. 496.

Coronal plates low, broad, numerous in the broad interradia (9–15), two vertical rows of primary tubercles which are perforate and crenulate, and with scrobicules which run the one into the other vertically. Median interradial area smooth, between broad angular zones.

Ambulacra very narrow, straight; pairs of pores in simple series; pores separated by a nodule; interporiferous areas with two vertical rows of very small and numerous tubercles or granules.

Fossil. Oolite: Europe.*

* *Leptocidaris*, Quenst., 1858, pl. 90. fig. 10; 1874, Petr. Deutschl. p. 232, tab. 69. figs. 71–71 *y*. This name was given to a fragment in which the coronal plates are numerous and low, and the pairs of pores are in simple series.

In Quenstedt's last work, 1874, the anatomy of an ambulacral plate is given, and it is not that of a Cidarid. The genus is placed after the Hemicidaridæ, p. 55.

Family CIDARIDÆ.

Section II.

The ambulacral pairs of pores biserial.

Genus DIPLOCIDARIS, *Desor*, 1854–58, *Synopsis*, pp. 45 & 439. *Cotteau*, 1862, *Rev. et Mag. Zool.* vol. xiv. p. 185, pl. 10.

Test large, spheroidal, wider than high.

Apical system large, solid, pentagonal, flush.

Ambulacra narrow, straight; poriferous zone as broad as the interporiferous area; pairs of pores very numerous, close, biserial, alternating more or less, placed in low primary plates which are single actinally, and which form compound plates elsewhere, these being double or triple combinations of low primary plates. Interporiferous area narrow, with two vertical rows of large granules with mamelons and a narrow, bare median space.

Interradia broad; plates few, high, 7–8; two vertical rows of large, perforate, scrobiculate, primary tubercles, which may or may not be crenulated, in each area; miliary zones large, with scattered granules.

Peristome narrow, with narrow ambulacral lips; branchial incisions absent. Jaws strong; the foramen of the pyramid small or absent. Perignathic girdle with interradial ridges only, and they are notched and bilobed.

Spines long, thick, cylindrical, granular, and pustulate in longitudinal ridges.

Fossil. Oolite: England?; Europe; N. Africa.

The next genus is placed here provisionally; it has four coronal interradial plates in each interradium, but not in every part of the areas; and the nature of the peristome is unknown in the species. The shape and the construction of the ambulacra are very remarkable; and it must be remembered that A. Agassiz found divisions in the interradial plates of *Astropyga radiata* ('Challenger' Echini, pl. x *a*. fig. 9, 1881).

Genus TETRACIDARIS, *Cotteau*, 1872, *Rev. et Mag. de Zool.* sér. 2, vol. xxiii. p. 445, pl. 29.

Test large, circular in equatorial outline, tumid, broader than high, depressed, spheroidal.

Apical system central, large.

Ambulacra straight, moderately broad; poriferous zones depressed, pairs incompletely biserial; plates low, primaries numerous. Interporiferous area narrow, granular, and with a vertical row of small plain tubercles, placed near each poriferous zone.

Interradia with numerous very large crenulate and perforate primary tubercles, in scrobicules, separated by a narrow median zone with few miliaries; there are four vertical rows of tubercle-bearing plates as far as the ambitus, diminishing thence to the apex by two. The plates are numerous, in vertical succession (16).

Peristome ?

Spines narrow, elongate, subcylindrical, keeled.

Fossil. Cretaceous: Europe.

This is a very suggestive, but at the same time, on account of the defective anatomical details, a most unsatisfactory genus.

The resemblance to *Astropyga* and the very non-Cidaridean characters of the ambulacra render the classification merely provisional. (See *Astropyga*, p. 78.)

Order II. DIADEMATOIDA (p. 24).

It is impossible to proceed with the classification of the next important group of genera of this Order without some remarks concerning the anatomical characters of the Streptosomata and the method of classifying the Family Diadematidæ of the Stereosomata. The late Dr. S. P. Woodward described a flexible Echinoid from the Chalk in 1863, and the knowledge regarding the recent forms commenced with Grube, who described *Asthenosoma* in 1868. Then the dredgings of H.M.S. 'Porcupine' revealed to the late Sir Wy. Thomson the extraordinary spectacle of a panting, plate-moving form, which he called *Calveria*. The descriptions of the species, which turned out to belong to *Asthenosoma*, were published in the Phil. Trans. 1874, and illustrated. The importance of the "imbrication" of the plates was inculcated, and the bearing of this structure upon the classification of the Family, and upon the possible alliances with the Perischoechinidæ, was rather overstrained. Unfortunately the very arduous life and necessary

absence from England of Sir Wy. Thomson prevented him from giving more time to the study of the specimens, so that some errors were published. It is evident, however, that the mistake made about the direction of the imbrication of the plates in 'The Depths of the Sea' was corrected in the Phil. Trans. 1874. But the description and drawing of the continuation of interradial overlapping plates beyond the peristome to the true mouth were unfortunate and so was the failure to recognize the external branchiæ. Some of the internal structures were described, such as the series of longitudinal muscles running up the sides of the ambulacra, and having to do with the positive motions of the plates one over the other; but, incomprehensibly enough, the huge internal branchiæ were not recognized, and their discovery has fallen to the Drs. Sarasin in 1888! A. Agassiz, in his Report on the Challenger Echini, 1881, considered the question of the amount of the imbrication of the plates of the Echinothuridæ—its cause, nature, and its relation to bevelling in thicker Palæechinoidea. These phenomena were exhaustively and most judiciously explained.

Nothing can be more definite than the description of A. Agassiz of the construction of the test of *Asthenosoma pellucidum*, A. Ag. He remarks that the test is remarkably thin, and that even in a test of the diameter of 64 millim. the plates do not give the test any degree of solidity. The examination of a specimen of *Phormosoma luculentum*, A. Ag., in the British Museum proves the comparatively large size of some of the interradial plates, but they are excessively thin, consist of very open reticulate carbonate of lime, and they thin off at the edges, the calcareous structure being lost in the membranous part of the plate. This membranous part is continuous between plates, and the soft edge of one plate merges into the corresponding membranous part of the neighbouring plate.

In *Asthenosoma coriaceum*, A. Ag. ('Challenger' Report, pl. xvii. *a*. figs. 5–7), the amount of soft interplate tissue is considerable; in some places the plates show an extremely small calcareous part, and the excess of soft tissue is great. The semi-transparency of some species, when kept in alcohol, is remarkable, and the calcareous part of the plates is seen to be surrounded by a greater or less amount of soft movable, but probably not extensible, connective tissue—that is, of uncalcified plate-area. The flexibility of such tests is considerable in large parts of them,

and it is of course less when the pressure is localized; they may be bent inwards and swell out elsewhere correspondingly. During life, movements of the test occur, and it is doubtless due to the contraction and dilatation of the internal longitudinal muscles, noticed and drawn by Wy. Thomson, and so well described and drawn by the Drs. Sarasin, as well as to gravitation. During this contraction and also after death the edges of the plates, especially the transverse edges, are approximated and slip over or under each other as the case may be. Nothing can be clearer than the drawings of A. Agassiz in regard to *Phormosoma tenue* ('Challenger' Report, p. 93, pl. xviii. *a*. figs. 1–13). The whole of the transverse edge of a plate overlaps that of its fellow in succession. The fig. 4 has no overlap of edge, fig. 5 has it slightly, but not figs. 2, 7, 8. The amount of overriding is small, and is assisted to a small degree by the thinning of the edges of all the plates, but there is no such thing as a bevelled thick edge.

In the drawing given by Sir Wy. Thomson (*op. cit.* 1874, pl. lxv. fig. 2), which shows the inner part of a test of *Asthenosoma* below the ambitus, the pairs of pores situated in the transverse sutural spaces are not forced out of their direction; hence the overriding must be very slight there. There is, on the other hand, definite but limited overlap of the interradial plates. The amount of interplate membrane varies in the species of *Phormosoma*, and it is less on the whole than in those of *Asthenosoma*, and yet the amount of overlap is only partial in this genus. The species *Phormosoma rigidum*, A. Ag., has a significant name, and it is evident that the interplate membranes are reduced to their utmost; there is no appreciable space between the plates in the drawing (Report on the 'Challenger' Echini, pl. xii. *a*. figs. 1–4, p. 104); all the other generic characters are present, but this is not a flexible and "panting" form, and has most significant alliances with the Diadematidæ.

The pistol-shaped outlined plates of *Asthenosoma* do not imbricate on most of their transverse edges, but the overlap is perfect at the median line of both areas, and a flap of plate must be more or less permanently overlapped or underlapped by another there. The ambulacral plates within the peristome, clearly overlap, and in order that the movement shall be uncontrolled there, the tentacles are associated with pores which are seen upon the plates themselves, and they are not upon the interplate structure.

In both genera of recent Echinothuridæ a special character

is the imperfect calcification of plate areas; the plates are therefore surrounded by soft tissue, and that of one plate is continuous with those of its neighbours, without close suturing.

It must be admitted that the overlap in *Astropyga* is rather an overstrained analogue of that which occurs in *Asthenosoma*; it is slight and persistent in *Astropyga*, and there is no movable soft tissue between the plates.

The interesting work of the Drs. Sarasin upon *Asthenosoma* shows that the longitudinal internal muscles have to do with the movements of the plates. The same authors discovered five large tubular branchiæ (Stewart's organs), passing out below the "compasses" and occupying much vertical space in the ambulacral areas, so that an exaggerated condition of what was formerly considered peculiar to the Cidaridæ prevails. The outer branchiæ were well drawn by A. Agassiz. The jaws and teeth resemble those of *Cidaris*, but the perignathic girdle has ambulacral processes, besides ridges upon the interradia. The want of interradial peristomial membrane plates is another important character which separates the genera from *Cidaris*; and the ambulacral plates differ entirely in their method of construction from those of that genus, and approach those of the Diadematidæ very slightly. The construction of the apical system is almost anomalous.

It is certainly not correct to state that the alliance of the Echinothuridæ is close with the Palæechinoidea, for there is but slight resemblance between the thick-plated forms of Archæocidaridæ and the group now under consideration. Even those genera of the Perischoechinoidea with bevelled plates which are all thicker than those of the Echinothuridæ, show no evidence of defective calcification nor of the presence of interplate, movable membrane, and the structural characters of *Asthenosoma*, for instance, are scarcely recognized. A. Agassiz has shown that considerable bevelling occurs in some thick-plated spherical Mesozoic and recent Echinoidea, and it does not appear to have been accompanied by movement and flexibility. *Pelanechinus* of the Oolites is the earliest known Echinothurid, and it is more Diadematoid than its successors.

During the Oolitic age there was evidently much variability in the structures of the ambulacra of the original Diadematidæ, and the entrance of the radial plates within the periproctal ring was not uncommon. It appears more reasonable to place the

Echinothuridæ near the Diadematidæ, granting some atavism, than to station them at the end of the Palæechinoidea; the alliance is with the first group, and the descent was probably not through the line of Cidaridæ and Saleniidæ.

The presence of rudimentary internal branchiæ in *Diadema*, according to Ludwig and the Sarasins, is another link with the Diadematidæ. It is proposed to place the Echinothuridæ in a suborder of the Gnathostomes with external branchiæ, the Streptosomata.

With regard to the Family Diadematidæ and its 36 fairly-defined groups, it may be said that the artificial method of classifying with the aid of crenulation and non-crenulation of tubercles gives way to the natural method in which the structure of the ambulacral plates is of primary taxonomic importance. Six former genera become subgenera, and the recognized genera are grouped in 4 very useful Subfamilies (p. 59).

I. Suborder **Streptosomata** (p. 25).

Family ECHINOTHURIDÆ, *Wy. Thomson*, 1873, *Depths of the Sea*, p. 164; 1874, *Phil. Trans. Roy. Soc.* vol. clxiv. pt. 2, p. 730. *A. Agassiz*, 1881, *Report on 'Challenger' Echini*, p. 71. *Ludwig*, 1880, *Zeitschr. für wiss. Zool.* vol. xxxiv. *P. & F. Sarasin*, 1888, *Ergebn. Naturw. Forsch. auf Ceylon*, Bd. i. Heft 3, p. 129.

Moderate to very large, tumid or very depressed, thin, flexible tests. The apical system with the plates usually separated. Coronal plates with membranous edges, with imperfect development of the calcareous element, which is highly and openly reticulate and usually thin. Ambulacral plates simple or compound, with small plates intercalated in the membranous areas, and tentacle-bearing, simple, low, perforated plates, within the peristome, imbricating adorally. Tentacles triserial and heteropodous. Interradial plates variable in shape, variably overlapping and in the opposite direction to the ambulacral plates. External branchiæ small, internal very large. Spheridia may be present. A series of internal longitudinal muscles. Jaws with a small foramen without epiphyses, teeth grooved; perignathic girdle continuous. Spines short, may be sheathed and capped or not at the end, hollow and largely cellular within and with solid wedges externally. Epistromal structures often highly developed.

Subfamily *Pelanechininæ.*

Syn. *Pelanechinidæ*, Groom, 1887, Quart. Journ. Geol. Soc. vol. xliii. p. 703.

The ambulacral plates compound above the peristome, those near the apex consisting of an adoral primary and six aboral demi-plates; plates near the ambitus large and pentagonal, with the pairs of pores triserial (in three ranks), the demi-plates remotest from the ambulacro-interradial suture, isolated.

Genus *Pelanechinus.*

Subfamily *Echinothurinæ.*

Ambulacral plates above the peristome; abactinally with a single large primary associated with two small demi-plates, which are placed in the transverse membranous areas; actinally with a primary plate associated with one or usually two demi-plates, which are situated in or near the ambulacro-interradial sutural line, or remote and isolated, or arrangement confused. Pairs of pores triserial. Plates within the peristome low primaries, each with a pair of pores.

Genus *Echinothuria.*
Phormosoma.
Asthenosoma.

Subfamily *Pelanechininæ* (supra).

Genus PELANECHINUS, *Keeping*, 1878, *Quart. Journ. Geol. Soc.* vol. xxxiv. p. 924. *Groom*, 1887, *ibid.* vol. xliii. p. 703. (*Adapted.*)

Test large, circular, tumid, depressed, thin, flexible. Apical system wanting.

Ambulacra less than half the width of an interradium, still broad at the peristome, beyond which they are continued. Apically the plates are composed of an adoral primary and two aboral demi-plates, and at the ambitus there are nine components, three of which are primaries, some demi-plates isolated; throughout the poriferous zones to the peristome, the pairs of pores are triserial; beyond the peristome the ambulacral plates are simple, broad, and perforated, the pair of pores in each oblique. A vertical row of plain primary perforated tubercles on either side of the median ambulacral suture.

Interradia with numerous coronal plates which are low, broad, and imbricating more or less, and with four vertical rows of plain primary tubercles at the ambitus, resembling those of the ambulacra, and diminishing in number and size actinally and abactinally, some secondary tubercles.

Peristome large; branchial notches deep. Jaws powerful, with grooved teeth. Spines small, hollow, longitudinally striated. Pedicellariæ small, tridactyle around the peristome, gemmiform orally, large tridactyle aborally.

Fossil. Oolite: England.

The above generic definition has been taken mainly from Mr. Groom's admirable description of the solitary species.

Subfamily *Echinothurinæ* (p. 41).

Genus ECHINOTHURIA, *S. P. Woodward*, 1863, *Geologist*, vol. vi. pp. 327–330. *Wright*, 1870, *Pal. Soc., Brit. Foss. Ech. Cret. Form.* p. 124.

Test large, plates imbricating, in both areas and in opposite directions. Apical system wanting.

Ambulacra wide at the ambitus, narrower towards the peristome; plates rather high; complete overlap of the adoral edge of one plate upon the corresponding aboral edge of the actinally placed plate, no space left; overlap of the outer edges of the plates by the interradial plate edges. A pair of pores in a primary plate and two pairs in small demi-plates in the position of the adoral suture. Buccal plates imbricating and perforated, ambulacral only. Tubercles small and scanty.

Interradia with larger plates, each in contact throughout its breadth with the plate above and actinally, and overlapping in the contrary direction to the ambulacral plates. Tubercles rare, not large, perforated, the same actinally as dorsally. Spines cylindrical, striated, with a milled ring. Jaws stout. Ornamentation scanty, and similar actinally and dorsally.

Fossil. Upper Cretaceous: England.

Genus PHORMOSOMA, *Wy. Thomson*, 1873, *Phil. Trans. Roy. Soc.* vol. clxiv. pt. 2, p. 732 (1874). *A. Agassiz*, 1881, *Report on 'Challenger' Echini*, p. 91; *Report on 'Blake' Exped. Echini*, 1883, p. 35.

Test small to large, thin, more or less flexible, tumid or depressed dorsally, flat actinally, circular or polygonal in ambital

outline; the structures of the abactinal and actinal surfaces differing. Plates numerous, thin, and surrounded by membrane, imbricating more or less.

Apical system star-shaped, large; plates united by membrane; basals projecting into the interradial median line, separated from the radials by periproctal plates and membrane; madreporite large. Periproct with small spine-bearing plates.

Ambulacra straight, broad; plates low abactinally, high and complicated actinally; a pair of pores in each plate, and a pair in each of the two small accessory plates along the adoral or the ambulacro-interradial suture; buccal plates continuous with those of the ambulacra, low, broad, pore-penetrated, overlapping. Primary tubercles of the interporiferous areas few, small, larger at the margin, more numerous actinally, perforate, scrobiculate; plates with granules.

Interradia with numerous low and broad plates, partly but broadly overlapping from below upwards, or connected all along the transverse sutures by membrane. Tubercles larger than in the ambulacra, smaller and most numerous actinally.

Peristome moderate, branchial incisions small, external branchiæ distinct. Perignathic girdle slender. Spines short, longest and most numerous actinally, where some are capped with a hoof-shaped process, others club-shaped or like long and short needles, striated and cylindrical in section, may be sheathed. Pedicellariæ some long and blunt-headed, others with very open valves, and many tridactyle and blunt-headed. Actinal tentacles disciferous, and the abactinal are pointed and branchial.

The plates, especially of the ambulacra, often seem to be split up in a remarkable manner. Spheridia may exist.

Recent. N. Atlantic to Azores; Caribbean Sea, and to the N., Japan, Philippines, Sandwich Islands, Low Archipelago, E. Pacific, Australia, Juan Fernandez to Chili. 120 to 2750 fathoms.

Genus ASTHENOSOMA, *Grube*, 1868, *Jahresb. d. Schles. Ges. f. Vaterl. Cult.* p. 42. *A. Agassiz*, 1872, *Revision*, p. 272; *Ech. of 'Blake' Exped.* 1883, p. 29. *Ludwig*, 1880, *Zeits. f. wiss. Zool.* vol. xxxiv. *P. & F. Sarasin*, 1888, *Erg. Nat. For. auf Ceylon*, Bd. i. Heft 3, p. 129.

Syn. *Calveria*, Wy. Thomson, 1873, Phil. Trans. Roy. Soc. vol. clxiv. pt. 2, p. 737.

Test moderate to very large, tumid at the circular or slightly polygonal ambitus, swollen, subhemispherical or depressed abactinally, flat actinally; more or less flexible. The calcareous deposits of the plates limited, the edges of the plates membranous.

Apical system central, polygonal, projecting; the plates separated by membrane, and some anal plates intervening between the basal and radial plates. Periproct small; anus projecting.

Ambulacra straight, broad at the ambitus; plates very numerous and much bent vertically, overlapping from above actinally, and overlapped by the ends of the interradial plates; a pair of pores in each plate, and two small plates in the adoral sutural membrane, each with a pair of pores. Plates continued from the peristomial edge to the mouth, imbricating, each plate broad, low, and pore-pierced. Small primary perforate, non-crenulate, areolated primary tubercles, in two or more vertical rows.

Interradia with numerous broad, low, pistol-shaped plates, united by membrane along the transverse edges, and expanded and overlapping at the median line; overlap in the opposite direction to that of the ambulacra; two or more vertical rows of primary tubercles resembling those of the ambulacra.

Peristome with small branchial incisions; internal branchiæ very large and five in number, the external branchiæ small; lower tentacles with prehensile discs, the abactinal pointed and branchial. Perignathic girdle weak, but with a decided arch between continuous processes.

Jaws with a small foramen; teeth grooved. Spines delicate, hollow, fenestrated, longitudinally striated and ridged, variable in length, but never very long; the secondary spines small, sharp and numerous, pointed, some sheathed. Pedicellariæ numerous, various, tridactyle, four-valved, some sharp and others blunt-ended.

Recent. N. Atlantic to coast of Portugal, Florida, Caribbean Sea, China Seas, Java, Philippines, Indian Archipelago, Ceylon, Fiji, New Zealand. From 100 to 450 fathoms.

III.

The Suborder Stereosomata and its Families. The Family Saleniidæ and its Genera. Family Hemicidaridæ and its Genera. Family Diadematidæ; its Subfamilies and Genera. Genus incertæ sedis. Family Cyphosomidæ and Genera. Family Arbaciidæ and Genera. Family Temnopleuridæ; Subfamilies and Genera.

II. ORDER.

II. Suborder **Stereosomata** (p. 25).

I. Family Saleniidæ.
II. „ Hemicidaridæ.
III. „ Aspidodiadematidæ.
IV. „ Diadematidæ.
V. „ Cyphosomidæ.
VI. „ Arbaciidæ.
VII. „ Temnopleuridæ.
VIII. „ Echinometridæ.
IX. „ Echinidæ.

I. Family Saleniidæ, *Duncan and Sladen*, 1887, *Ann. & Mag. Nat. Hist.* ser. 5, vol. xix. p. 117.

Regular ectobranchiate gnathostomes, with a persistent dorso-central plate or plates; madreporite in the right anterior basal plate. Ambulacra narrow, the plates numerous, simple low primaries, rarely in compound plates actinally. Interradial plates few and tubercles large. Peristome with branchial incisions and external branchiæ. Perignathic girdle with interradial ridges and ambulacral processes united or not. Jaws with the foramina of the pyramids unarched by epiphyses; teeth with a keel. Spheridia present. Spines very variable, cellular with a solid superficies.

Division I.
Genus *Peltastes*.
Syn. Hyposalenia; Pseudosalenia; Poropeltis.
Subgenus *Goniophorus*.
Genus *Salenia*.
Subgenus *Heterosalenia*.

Division II.
Genus *Acrosalenia*.

Division I.

Ambulacral plates simple.

Genus Peltastes, *Agassiz*, 1838, *Monogr. d'Éch. viv. et foss.* livr. i. p. 27, pl. v. (non *Desor*, 1858, *Synopsis*, p. 145). *Duncan & Sladen*, 1887, *Ann. & Mag. Nat. Hist.* ser. 5, vol. xix. pp. 129–132. (*Amended.*)

Syn. *Pseudosalenia*, Cotteau, 1859, Rev. et Mag. de Zool. vol. xi. sér. 2, p. 215. *Hyposalenia*, Desor, 1858, Synopsis, p. 147. *Poropeltis*, Quenst., 1858 and 1872–5, Petr. Deutschl. tab. 69.

Test small, circular in outline, tumid at the ambitus, depressed and slightly tumid abactinally, or tall, and with a part of the apical system projecting, actinally rather flatly curved.

Apical system large, raised slightly, and part of it usually projecting, with large basals and small radials; a small dorso-central plate, in the long axis of the system, united to the lateral basals, but not touching the posterior basal; incurved posteriorly for the anterior margin of the anus. Radials large, not within the ring. Periproct posterior and bounded in front by the dorso-central plate, and posteriorly and laterally by the basals 4, 5, and 1. The sutures of the disk often grooved, marked with depressions and the prolongation of the ornamentation of the basal and dorso-central plates; these plates have grooves and eminences often radiate in arrangement, margins of the basals often variously curved and notched.

Ambulacra narrow, straight or slightly flexuous, with small primary tubercles near the poriferous zone; plates low primaries only. Interradia with large primary tubercles diminishing in size above and below the ambitus, crenulate or not and imperforate.

Peristome small, rather reentering, slightly incised. Perignathic girdle with low broad ridges and slender unarched processes.

Fossil. Cretaceous: England. Upper Jurassic and Cretaceous: Europe. Cretaceous: N. Africa.

Subgenus GONIOPHORUS (genus), *Agassiz*, 1838, *Monogr. d'Éch. viv. et foss.* livr. i. p. 30. *Cotteau*, 1861, *Bull. Soc. Géol. France*, sér. 2, vol. xviii. p. 624. *Duncan and Sladen*, 1887, *Ann. & Mag. Nat. Hist.* vol. xix. pp. 131–132.

Test small, swollen, subspheroidal, with large peristome, few interradial primaries, upon high plates. Apical disk pentagonal, with five large basals and five small radials, ornamented with linear, raised and straight keels which are not on the lines of the sutures; dorso-central plate large, the periproct posterior to it and elongate transversely. Pits for spheridia large in the narrow ambulacra actinally.

Fossil. Upper Greensand: England, Europe, N. Africa.

Genus SALENIA, *Gray*, 1835, *Proc. Zool. Soc. Lond.* pt. 3, p. 58. *L. Agassiz*, 1838, *Monogr. d'Éch. viv. & foss.* livr. i. p. 6. *A. Agassiz*, 1874, *Revision of the Echini*, p. 258; 1883, *Blake, Ech.* p. 13. *Duncan & Sladen*, 1887, *Ann. & Mag. Nat. Hist.* ser. 5, vol. xix. p. 132. (*Amended.*)

Test small, subglobose or depressed. Apical system larger than the peristome, more or less raised. The dorso-central plate more or less geometrical, imperfect, and eroded at the right posterior angle by the periproctal ring, in contact with all the basals. Apical plates ornamented with radiating grooves and ridges. Radial plates large, with the pore in the adoral edge, one plate may or may not enter the periproctal ring. Periproct large, with a plated membrane pierced by the anal opening.

Ambulacra narrow, with two rows of small primary tubercles and granules; plates all simple primaries, crowding rare near the peristome. Pairs of pores in simple vertical series; tentacles sub-homoiopodous. Interradia with large primaries. Tubercles of both areas crenulate, or some plain, and imperforate.

Peristome with cuts for the external branchiæ, with a membrane plated or not. Perignathic girdle with broad ridges and slender ununited processes; jaws with the foramen of the pyramid small, unarched; teeth with a keel. Spines of primaries long, slender, variable in ornamentation; small spines club-and wedge-shaped and flat. Pedicellariæ of the three kinds; epistroma often much developed. Spheridia exist.

Fossil. Cretaceous: England, Europe, Asia, North and West Africa. Eocene: Europe, Asia. Miocene: Australia.

Recent. Caribbean Sea, both of the great Oceans, Japanese Sea. Depth from 60 to 1700 fathoms.

Subgenus HETEROSALENIA (genus), *Cotteau*, 1861, *Pal. Franç., Terr. Crét.* p. 96, pl. 1022. *Duncan & Sladen*, 1887, *Ann. & Mag. Nat. Hist.* ser. 5, vol. xix. p. 132.

The primary tubercles are perforated.

Fossil. Cretaceous: Europe.

Division II.

In the second division of the genera of the Family the ambulacral plates are compound at a short distance from the apical system, and the pairs of pores are crowded near the peristome.

Genus ACROSALENIA, *Agassiz*, 1840, *Éch. foss. de la Suisse*, pt. 2, p. 38. *Duncan & Sladen*, 1887, *Ann. & Mag. Nat. Hist.* ser. 5, vol. xix. p. 128.

Test moderate in size, depressed, tumid at the circular and rarely pentagonal ambitus, rounded above, flatter actinally.

Apical system rather large, four anterior basals large, and the posterior smallest and differing in shape. A dorso-central plate in the antero-posterior axis of the system, in contact with the four larger basals and anterior to the periproct. Supplementary plates to the dorso-central may occur. Posterior radial plates enter the ring of the periproct, rarely a radial separating the antero-lateral and postero-lateral basals. Periproct large and posterior.

Ambulacra narrow, with primary plates near the apical system and with compound plates near the ambitus and actinally. Compound plates of united primaries with rare demi-plates, except near the peristome. Pairs crowded and biserial near the peristome, from the presence of demi-plates. Tubercles of the interradia largest, perforate and crenulate; those of the ambulacra much smaller, or only as large granules.

Peristome large, decagonal, with well-developed branchial grooves with raised edges. Perignathic girdle with low ridges and slender processes sometimes uniting. Spines large and small, the former striated longitudinally, or plain, and often not quite circular in transverse section; smaller spines striated.

Fossil. Lias and Oolites: England and Europe. Lower Cretaceous: N. Africa.

II. Family HEMICIDARIDÆ, *Wright*, 1857, *Pal. Soc.*, *Ech. Ool. Form.* p. 68. (*Amended.*)

Regular ectobranchiate gnathostomes with the test thick, more or less spheroidal, depressed or tall or subconical. Ambulacra increasing in width actinally; primary tubercles well developed, but smaller than those of the interradia, extending or not throughout in two vertical rows; pairs of pores in arcs actinally where the plates are compound. Interradia large, plates few; tubercles very large at the ambitus, variously sized actinally and dorsally, and may be obsolete there. Scrobicules often coalescing. Peristome decagonal, ambulacral lips large, branchial incisions well developed. Perignathic girdle with interradial ridges and united

ambulacral processes. Jaws large, foramen large, without epiphyses; teeth grooved. Spines often large, variable, and usually solid.

Genus *Hemicidaris*.
Subgenus *Hemidiadema*.
„ *Hypodiadema*.
„ *Pseudocidaris*.
„ *Asterocidaris*.
Genus *Acrocidaris*.
Subgenus *Acropeltis*.
Genus *Goniopygus*.
„ *Circopeltis*.
„ *Cidaropsis*.
„ *Glypticus*.
Genus incertæ sedis: *Leptocidaris*, Quenst.

Genus HEMICIDARIS, *Agassiz*, 1840, *Éch. Foss. de la Suisse*, pt. ii. p. 42. *Desor*, 1858, *Synopsis*, p. 50. *Duncan*, 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 436. (*Amended.*)

Syn. *Tiaris*, Quenst.; *Hemipygus*, Étallon (immature).

Test of moderate size, spheroidal, tall, tumid at and above the ambitus, flattish and often broadest actinally.

Apical system small, either with large united basal plates (or some or all radial plates enter the periproctal ring *).

Ambulacra narrow, enlarging near the ambitus, projecting or not; the plates a multitude of small low primaries near the apical system, succeeded by compound plates which may be formed by two to four constituents, their arrangement partly "Diadematoid," but with additional primary or demi-plates, placed abactinally to the large tuberculous primary plate. Pairs of pores simple abactinally, in arcs near the large tubercles, and crowded near the peristome. Tubercles in two vertical rows, perforate and crenulate, large to varying distances above the ambitus, and then diminishing in size or replaced by granules.

Interradia broad, with but few high coronal plates, with two vertical rows of large, projecting, perforate and crenulated primary tubercles, larger than those of the ambulacra. Scrobicules usually contiguous and incomplete; secondary tubercles and granules.

Peristome large and the branchial incisions well developed. Pyramids of the jaws with a large incomplete foramen; teeth

* Very rare, or probably in subgeneric groups only.

grooved. Spines large, some needle-shaped, others club-shaped and longer than the test's diameter, some knob-ended, others forked, longitudinally striated, some marked across.

Fossil. Zechstein, Alpine Trias, Lias, Oolites, Cretaceous: Europe. Oolites: England. Jurassic, Tithonian, and Cretaceous: N. Africa.

This important genus has several fairly well marked subgenera (formerly genera). It appears that the genus *Hemipygus*, Étallon, 1850, Études Pal. Haut-Jura, suppl. p. 4, relates to small, young, and immature *Hemipygi*. As is usual in Echinoidea only 4 millim. in height and 8 millim. broad, the apical system is exaggerated in size and the genital perforations are variable. It is placed as a synonym of *Hemicidaris*.

Subgenus HEMIDIADEMA (genus), *Agassiz*, 1840, *Ech. Suisse*, pt. ii. p. 47. *Étallon*, 1859, *Lethæa Brunt.* p. 326.

The tubercles of the ambulacra large and few in number below the ambitus, alternating distinctly.

Fossil. Oolites and Cretaceous: Europe.

H. stramonium, Agass., is the type; but *H. rugosum* does not belong to the genus, it is a *Glyphocyphus*, Haime.

Many of the species of the next subgenus have been determined from immature specimens; this is especially the case with the St.-Cassian forms.

Subgenus HYPODIADEMA (genus), *Desor*, 1858 (pars), *Synopsis*, p. 61. *Laube*, 1865, *Denks. Akad. Wiss. Wien*, vol. xv. p. 295. *Zittel*, 1879, *Handb. d. Pal.* p. 501.

Ambulacra narrow, straight, with two rows of small, crenulate, perforate primaries (?), nearly maintaining their size throughout, diminishing but slightly abactinally. Interradia with large primary tubercles, in two vertical rows extending to the apex; plates granular beyond the scrobicules.

Peristome and the branchial incisions small. Spines cylindrical and smooth.

Fossil. Oolite: England? Trias, Oolites, and Cretaceous: Europe.

The Cretaceous species have variable branchial incisions, and in one the primary interradial tubercles do not reach the apex.

Subgenus Pseudocidaris, *Étallon* (genus), 1859, *Lethæa Brunt.* p. 333. *Cotteau*, 1882, *Bull. Soc. Zool. de France*, vol. vii. p. 1. *De Loriol*, 1887, *Rec. Zool. Suisse*, vol. iv. p. 336, pl. xv. figs. 2–"*b*."

Ambulacra very undulating abactinally, narrow, with primary tubercles only near the peristome, granules elsewhere. Interradia broad, with few coronal plates, and two vertical rows of large primary tubercles, distant. Spines large, massive, cylindroid or fusiform, or pear-shaped, striated longitudinally or granular.

Fossil. Oolite and Cretaceous: Europe, N. Africa, Mexico.

The genus *Asterocidaris*, Cotteau, 1859, has all the characters of *Hemicidaris*, and it appears that the existence of star-shaped or triangular bare spaces in the median interradial areas near the projecting basal plates is not of generic importance. *Asterocidaris* should be placed as a subgenus of *Hemicidaris*, with the following characters:—

Subgenus Asterocidaris, *Cotteau*, 1859 (genus), *Rev. et Mag. de Zool.* sér. 2, vol. xi. p. 159.

Apical system large, with basal plates projecting adorally into a bare median interradial space; interradial plates ten or less in number in each vertical series.

Fossil. Europe.

Genus Acrocidaris, *Agassiz*, 1840, *Ech. Foss. de la Suisse*, pt. ii. p. 10. *Desor*, 1858, *Synopsis*, p. 83.

Test large, tumid at the ambitus, and subconical or spheroidal dorsally, flat actinally.

Apical system small, some or all of the basal plates with a large perforate tubercle, the madreporite large. Periproct large.

Ambulacra straight, broad at the ambitus, with two vertical rows of large perforated primary tubercles, slightly smaller than those of the interradia, and extending to the apex; pairs of pores uniserial and in simple series near the apex, in arcs of from four to seven pairs near the larger tubercles, crowded and polyserial actinally; plates "diadematoid," with some additional components; sutural lines as grooves on the flanks of the tubercles.

Interradia with two vertical rows of large primary tubercles, only the largest being perforate and crenulated.

Peristome large, branchial incisions well developed. Spines cylindrical, smooth or finely striated, often tricarinate at the top.

Fossil. Oolitic: Europe and N. Africa. Cretaceous: Europe.

Subgenus ACROPELTIS, *Agass.* (genus), 1840, *Catal. Syst. Ectyp.* p. 19; *Éch. Foss. de la Suisse*, pt. ii. p. 27.

The primary tubercles of all the areas are imperforate and uncrenulate; the largest tubercles are actinal.

Fossil. Oolite: Europe.

The type of *A. concinna*, Merian, figured by Cotteau, 1861, Rev. et Mag. de Zool. vol. xiii. p. 76, is immature, it being only 1 millim. high and 2 millim. broad. Hence the large dorso-central system.

Genus GONIOPYGUS, *Agass.* 1838, *Monogr. d'Éch. viv. et foss.* livr. i. p. 19. *De Loriol*, 1887, *Faune Crét. du Portug., Éch.* fasc. i. p. 55.

Test small, depressed, hemispherical dorsally, circular in outline at the tumid ambitus, broader than high.

Apical system large and stout, the prominent basal plates close, polygonal, and angular adorally or almost square; sutures dentated, perforated, or otherwise ornamented; periproctal edges in ridges and notched; periproct small, triangular or square, and may be circular in outline; radial plates remote from the periproct, pentagonal and wide actinally, variously ornamented.

Ambulacra narrow, with two vertical rows of primary plain tubercles, smaller than those of the interradia, which are large, plain, and in two vertical rows. Pairs of pores in simple primary plates abactinally, but near the tubercles of the actinal surface the plates are triple compounds, there being an adoral demi-plate, a median primary, large, and an aboral primary; the sutures are convex towards the tubercle.

Peristome very large, with small branchial incisions. Spines small, club-shaped, striated or not.

Fossil. Cretaceous: Europe, N. Africa, Asia. Eocene: Europe.

The genus *Circopeltis* originated with M. Pomel, 1883, but his definition was not a positive one; he compared it with *Leiosoma*. M. de Loriol has, however, shown that the genus is not related to *Leiosoma* but to *Goniopygus*.

Genus CIRCOPELTIS, Pomel, 1883, *Thèses Class. Méthod. Éch. (Alger)*, p. 89. *De Loriol*, 1887, *Faun. Crét. du Portug., Éch.* fasc. i. p. 55, pl. ix. fig. 7.

Test small, subhemispherical, depressed dorsally, flat actinally. Interradial plates few (8–9).

Apical system solid, with or without radial plates entering the periproctal ring; periproct large and subcircular.

Ambulacra straight, expanding near the large tubercles, broad at the peristome, the interporiferous area with primary tubercles in two vertical rows, large at the ambitus, and smaller actinally, and smallest and distant abactinally, all are plain; poriferous zones with uniserial pairs of pores abactinally, in slight arcs near the large tubercles, and slightly crowded actinally; plates low, broad, simple primaries abactinally, compound at the ambitus and actinally, the adoral component a demi-plate and its pair of pores much nearer the median line than the other pairs, excluded from the ambulacro-interradial suture. The other components long; low primaries with an occasional demi-plate.

Interradia with two vertical rows of plain primary tubercles, largest at the ambitus; rows of secondary tubercles and granules.

Peristome moderate, with branchial incisions.

Fossil. Cretaceous: Europe, N. Africa (?).

The compound ambulacral plates are not without an affinity with those of the recent *Aspidodiadema*, A. Agass.

Genus CIDAROPSIS, *Cotteau*, 1860 (reference not to be found). 1882, *Pal. Franç., Terr. Jura*, livr. lvi. p. 433, pls. 376, 377.

Test moderate and rather small in size, swollen above and almost flat below, circular in outline at the ambitus.

Apical system solid and moderately developed.

Ambulacra subflexuous abactinally, enlarging at the ambitus, having small primary tubercles actinally which are smaller than those of the interradia, perforate and crenulate. Towards the apex the tubercles are replaced by granules. Poriferous zones undulating, with simple pores, close, and they multiply near the peristome.

Interradia broad, with few plates and two rows of large primary tubercles, perforate, non-crenulate and distant, with projecting scrobicules.

Peristome large, subdecagonal, and with large branchial incisions. Periproct subcircular. Spines large and glandiform.

Fossil. Europe: Jurassic formation.

Cotteau places the genus close to *Hemipedina*; but it appears to be nearer *Hemicidaris*.

Genus GLYPTICUS, *Agassiz*, 1840, *Éch. Foss. de la Suisse*, pt. ii. p. 95. *Desor*, 1858, *Synopsis*, p. 95. *Cotteau*, 1880–85, *Pal. Franç.*, *Éch. Terr. Jura*, pl. 418.

Test moderate in size, thick, subhemispherical, flat actinally.

Apical system large, slightly raised, the basals in contact, stout, sculptured; the sutures depressed, pitted more or less; the radial plates large, between the outer part of basals as broad as they are, pentagonal, broad and re-enteringly curved adorally. Periproct elliptical, or pentagonal with a raised rim, small.

Ambulacra straight, narrow, except at the peristome, where the poriferous zones are expanded. Poriferous zones straight, narrow, sunken; pairs in compound plates usually triplets, polyserial at the peristome; two vertical rows of small, smooth, primary tubercles, the mamelons confounded with the bosses, imperforate and non-crenulate, pass to the apex from the peristome, close to the poriferous zones; or the tubercles may be replaced above the ambitus by elongate smooth elevations of the plates placed irregularly or not. Epistroma much developed.

Interradia with large primaries resembling those of the ambulacra at the ambitus and actinally, but with warty or irregularly elongate elevations, with or without secondary tubercles, abactinally; granules and secondary tubercles exist.

Peristome large, decagonal, often deformed and longer in the antero-posterior direction than across, the branchial incisions well developed, and a notch at the ambulacral median line also.

Fossil. Oolite: England, Europe, and N. Africa.

Incertæ sedis.

Genus Leptocidaris, *Quenstedt*, 1858, *Der Jura*, pl. 90. fig. 10; and 1874, *Petr. Deutsch.* p. 232, tab. 69. figs. 71.

Test spheroidal; the ambulacra moderate and straight; the pores are in arcs of triple pairs, and each compound plate is large, higher than an interradial plate, and alternately broad and narrow; small perforated primary tubercles on alternate plates, or more distant.

The ambulacral plates have each a large adoral primary component, which carries the tubercle and a middle and aboral demi-plate.

Interradial plates low and broad.

Fossil. Jurassic: Europe.

The description is taken from that mine of wealth, Quenstedt's Petrefact. Deutschlands, Leipzig, 1874. The type is *L. triceps*, Quenst.

In the Report on the Echini of the 'Challenger' and 'Blake' Expeditions A. Agassiz described species of *Aspidodiadema*, a genus which he defined comparatively rather than positively. He gave his usual careful opinions regarding the affinities of the genus, and noticed how it links together the Cidaridæ and Diadematidæ. The descriptions of the species and the figures which illustrate them are so clear and definite that all the taxonomic difficulties surrounding them are really seized at a glance. A palæontologist would hardly hesitate to add *Hemicidaris* to the list of allied genera; and any naturalist who has studied the ancient and modern faunas would say that there is a wonderful union of almost excessive modern characters, and others characteristic of deep-sea dwellers, combined with the Hemicidaridean, accompanied by a Cidaroid ambulacral structure.

The paucity of interradial plates, each with a large perforate and crenulate tubercle, associated with branchial peristomial incisions, and without imbricating ambulacral and interradial buccal plates, there being only ten huge simple buccal plates, the ambulacral plates being low simple primaries, with or without large primary tubercles, may be said to be a jumble of characters which will prevent the forms being classified with the families Hemicidaridæ and Diadematidæ. It is proposed to form a family for the genus.

III. Family Aspidodiadematidæ.

Diadematoidea with spheroidal tests, having a large, narrow, ringed apical system formed by broad basals and broad intervening radial plates; having few interradial plates, each with a large primary perforate and crenulate tubercle; straight ambulacra with numerous low primary plates with or without primary tubercles; pairs of pores, one in each plate in straight vertical series. Peristome incised; branchiæ bifid, and with ten very large buccal plates; tentacles heteropodous. Spines hollow and striated, verticillate.

The generic definition given by A. Agassiz of *Aspidodiadema* is very comparative, and we therefore venture to give a positive diagnosis founded upon the study of the species which have been so admirably described and figured in the Reports on the 'Challenger' and 'Blake' Echinoidea *.

Genus Aspidodiadema, *A. Agassiz*, 1879, *Proc. Amer. Acad.* vol. xiv. p. 199; 1881, *Report on 'Challenger' Echini*, p. 64; 1883, *Report on 'Blake' Echini*, p. 24.

Syn. *Plesiodiadema*, Pomel, 1883, *non* Duncan. (*Adapted.*)

Test moderately large, tall, spheroidal, thin; interradial coronal plates few in number.

Apical system large, the narrow ring of plates composed of broad basals and of wide intervening included radial plates; the periproct large, the membrane with few or numerous radiating plates, some united and reaching from the ring to the anus, which may be tubular.

Ambulacra broad, with a few large primary perforated and crenulated tubercles sometimes reaching above the ambitus, and with smaller tubercles or granules abactinally, or with only small tubercles and loose granules throughout. The pairs of pores are numerous, in simple vertical series, and the plates are simple and low broad primaries. Tentacles heteropodous.

The interradia have two vertical rows of large primary perfo-

* The fact that *A. microtuberculatum*, A. Ag., has small tubercles on its ambulacra must not be forgotten; but at the same time it must be remembered that all the other generic characters are the same as those of the other species. It is hardly worth while, therefore, to disturb the genus, as has been attempted by a naturalist who has not seen the forms.

rated and crenulated tubercles, and with expanded bases, largest at and above the ambitus.

Peristome smaller than the apical system, with small branchial incisions and bifid branchiæ; ten very large spined buccal plates. Teeth grooved. Spheridia large and extending high up on the ambulacra. Spines hollow, verticillate, straight and curved, some large and very long, others similar and small. Pedicellariæ various, some with large glands upon the stem.

Recent. Caribbean Sea, 95–1200 fms.; N. part of the South Atlantic, and also the Chili coast, 356–2225 fms.; Philippine Sea, 100–1700 fms.

The Family Diadematidæ was well formulated by Cotteau and Wright, and the arrangement of the genera, by the existence or not of crenulation and perforation of the primary tubercles, has been very popular and useful; but it is too artificial, for the physiological importance of the superficial structures of the tubercles is exceedingly small. Careful consideration proves that many genera have been placed in the Family which can hardly remain, and they have now found places in the Families of Hemicidaridæ, Temnopleuridæ, Arbaciidæ, and Cyphosomatidæ.

Many genera have been introduced since Cotteau founded the Family, and it is now fairly homogeneous, if they are arranged with their fellows on the principle of the structures of the ambulacra being considered of primary taxonomic importance. It is the group of genera which is characterized by having numerous small tubercles placed actinally and at the ambitus, but then ceasing more or less, which has given much trouble. Such genera are *Codiopsis*, *Gymnodiadema*, *Plistophyma*, and *Polycyphus*. Again, *Orthopsis* and its allies are difficult to classify upon the old lines of the value of crenulation and perforation. It may be stated, as a general truth, that if these genera be classified by the ornamentation of the tubercles, groups possessing very diverse ambulacra will be associated.

The Family separates by the new method into subfamilies.

A most unfortunate decision of Desor's has made palæontologists and students of the recent fauna look upon some of the most important species of one genus in a very different light. Desor introduced the genus *Pseudodiadema* to take the place of fossil *Diademæ*. The only distinctions between the recent genus

and the one founded by Desor, which in the first instance was called by the same name as the recent forms (*Diadema* by Gray), are that there is no verticillation of the longitudinally striated spines of *Pseudodiadema*, and the spines are solid in the fossil, hollow in the recent form. These are possibly specific characters at the most, and hence one of the first steps in a revision must be the elimination of *Pseudodiadema*, with its host of species.

IV. Family DIADEMATIDÆ*.

Regular ectobranchiate gnathostomes, with or without rudiments of internal branchiæ, with highly ornamented, tumid, depressed, or spheroidal tests; with a well-developed dorso-central system, often with a tubular anal orifice; with the madreporite in the right anterior basal.

Ambulacra moderately broad or narrow, straight, flush or tumid, with vertical rows of primary tubercles resembling the interradial but usually smaller; pairs of pores either in simple series, or in arcs, or in two or more vertical series; the plates compound near the ambitus and actinally, low and numerous; the median component carrying the tubercle and reaching the median line, and therefore a large primary plate, and the adoral and aboral plates of the compound low, broad primaries, smaller than the median plate and having their sutural lines curved towards the tubercle of the median component; demi-plates rarely exist.

Interradia broad, with numerous low plates, with vertical rows of primary tubercles, and sometimes with more than one horizontal row of them on a plate; vertical rows varying in number, diminishing dorsally; tubercles resembling those of the ambulacra, but usually larger.

Peristome large, polygonal, with branchial incisions. Perignathic girdle continuous; processes arched and the ridges low. Jaws without a closed pyramidal foramen; teeth grooved. Tentacles heteropodous. Spheridia present. Spines variable, short or long, hollow, striated and grooved longitudinally, verticillate or not, (solid from fossilization).

* The definition is an amendment of Gray, 1835; Peters, Abhandl. d. königl. Akad. d. Wiss. Berlin, read 1853, published 1855, p. 106; A. Agassiz, 1874. For morphology see Quart. Journ. Geol. Soc. 1885, p. 419, Journ. Linn. Soc. vol. xix. 1885, pp. 95 and 201. Also P. and F. Sarasin, Ergebn. Naturw. Forsch. auf Ceylon, 1884–6, published 1887, Bd. i. Heft 1, pp. 1–17.

I. Subfamily *Diadematinæ*. Ambulacral plates compound, near the ambitus; the pairs of pores in simple vertical series or in arcs of threes.

I. Genus *Diadema* (syn. Pseudodiadema).
Subgenera *Centrostephanus*, *Microdiadema*, *Diademopsis*, *Hemipedina*, *Echinodiadema*.
II. Genus *Placodiadema* (syn. Plesiodiadema).
III. „ *Heterodiadema*.
IV. „ *Codiopsis*.
V. „ *Pleurodiadema*.
VI. „ *Magnosia*.
VII. „ *Cottaldia*.

II. Subfamily *Diplopodiinæ*. Ambulacral plates compound; pairs of pores biserial.

I. Genus *Diplopodia*.
II. „ *Pedinopsis*.
III. „ *Acanthechinus*.
IV. „ *Phymechinus*.
V. „ *Asteropsis*.
VI. „ *Diplotagma*.
VII. „ *Micropyga*.
VIII. „ *Plistophyma*.

III. Subfamily *Pedininæ*. Ambulacral plates compound; pairs of pores triserial.

I. Genus *Pedina*.
Subgenus *Pseudopedina*.
II. Genus *Echinopedina*.
III. „ *Stomechinus*.
IV. „ *Micropedina*.
V. „ *Heterocidaris*.
VI. „ *Echinothrix*.
VII. „ *Astropyga*.
VIII. „ *Polycyphus*.
IX. „ *Codechinus*.

IV. Subfamily *Orthopsinæ*. Ambulacra with simple primary plates; pairs of pores in simple series.

I. Genus *Orthopsis*.
II. „ *Eodiadema*.
III. „ *Peronia*.
IV. „ *Echinopsis*.
V. „ *Gymnodiadema*.

Genus incertæ sedis. *Progonechinus*.

I. Subfamily *Diadematinæ* (p. 59).

Genus DIADEMA, Schynvoet, 1711, *Thes. Imag. Pisc. &c.* p. 2, pl. xiv. *Gray*, 1825, *Ann. Phil.* vol. xxvi. p. 426. *Peters*, 1853, *Abhandl. k. Akad. Wiss. Berlin* (1854), p. 107. *Bölsche*, 1865, *Archiv für Naturg.* vol. xxxi. p. 325. *A. Agass.* 1874, *Revision*, p. 274. *Duncan & Sladen*, 1885, *Journ. Linn. Soc.* (*Zool.*), vol. xix. p. 95. *Lovén*, 1887, *On Species of Ech. desc. by Linnæus, Bihang till K. Svenska Vet.-Akad. Handl.* Bd. xiii. Afd. iv. No. 5, pp. 125–137. *Sarasin, P. & F.*, 1887, *Ergebn. Naturw. Forsch. auf Ceylon*, Bd. i. Heft 1, pp. 1–17.

Syn. *Pseudodiadema*, Desor; *Tetragramma*, Agass.; *Hebertia*, Mich.

Test thin, moderate in size, circular or slightly polygonal in tumid marginal outline, wider than high, rather depressed.

Apical system sunken or not, large; basal plates large, with a long outer angle and large duct-perforation; radial plates small and some may enter the periproctal ring. Periproct large, with a thin membrane furnished with a few plates near the ring. Anal orifice at the end of a tube.

Ambulacra straight, narrow, often projecting; pairs of pores in simple series in arcs; plates compound, each with a middle broad primary component carrying a tubercle and occupying much of the median sutural edge, having a long low primary above and below and occupying but little of the median sutural edge, the edges of these plates curved, convexity towards the base of the tubercle on the middle plate. Two vertical rows of small, primary, crenulate and perforate tubercles extending from peristome to apex.

Interradia with a bare median space near the apex or not; coronal plates long and low. Primary tubercles in two or more rows, resembling those of the ambulacra in structure, but larger; secondary tubercles and granules on the flanks of the scrobicules.

Peristome large, decagonal; branchial incisions with "tags." Actinal membrane thin, but slightly plated. Perignathic girdle with well-developed ridges; processes united and rather tall, a projection of the test beyond the ridges into the peristome. Jaws large; pyramids with a tall foramen open above; teeth grooved. Eye-spots numerous. Spines long, hollow, closely verticillate, striated longitudinally, milled ring prominent.

Fossil. Lias, Oolites, Cretaceous: England, Europe, N. Africa, Egypt, Asia, N. America. Eocene: Europe.

Recent. Caribbean Sea, Cape Verd, Indian Ocean, Red Sea, Japan, Pacific Ocean, W. coast of Central America.

Subgenus CENTROSTEPHANUS, *Peters*, 1853 (genus), *Abh. d. k. Akad. d. Wiss. Berlin*, 1854, pub. 1855, p. 109 (note). *A. Agass.* 1874, *Revision*, p. 409. *Duncan*, 1885, *Journ. Linn. Soc. (Zool.)*, vol. xix. p. 110.

Syn. *Echinodiadema*, Verr.; *Trichodiadema*, A. Agass.

Test thick, large or moderate, globular or depressed, circular at the tumid ambitus.

Apical system with basal plates separated by small, rectangular periproctal plates, and by radial plates also. Periproct with minute plates. Anal opening small.

Ambulacra with two rows of tubercles and the plates as in *Diadema*, but the poriferous zones may be sunken.

Interradia twice as broad as the ambulacra; four vertical rows of perforate and crenulate tubercles, two rows being more prominent than the others, all subequal; median space ill-defined.

Actinal membrane of the incised decagonal peristome with ten large plates carrying spines, pedicellariæ, and tentacles. Spines hollow, thin, very verticillate and striated longitudinally, long and slender, some small and club-shaped.

Recent. Mediterranean, Canaries, Australia, New Caledonia, W. coast of Central America.

Former genus PSEUDODIADEMA, *Desor*, 1858, *Synopsis*, p. 63, pars. *Duncan*, 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 430. *Cotteau*, 1864, *Rev. et Mag. de Zool.* 2 sér. vol. xvi. p. 288. (Now DIADEMA.)

Syn. *Tetragramma*, Agass.; *Hebertia*, Mich.

Test small and moderate in size, thin, tumid at the circular ambitus, swollen to subconical dorsally, depressed, flat or re-entering actinally.

Apical system small, ornamented; the periproct circular or somewhat elongate, and even unsymmetrical; basal plates narrow; radial plates small, equal or unequal, and some may enter the periproctal ring; the pore close to the adoral edge; madreporite distinct and in the right anterior basal plate.

Ambulacra much narrower than the interradia; plates as single low primaries near the apex and soon becoming compound, the central component with the tubercle, a primary, and the adoral and aboral constituents also primaries, their sutures curved, convexity towards the tubercle; sometimes a demi-plate near the peristome. Pairs of pores in simple straight series near the apex and in the same towards the ambitus, or in slight arcs

of triplets slightly crowded near the peristome; primary tubercles in two rows, perforate and crenulate, fairly developed.

Interradia wide, with two or more vertical rows of primary tubercles, larger than those of the ambulacra, and otherwise similar; secondary tubercles may exist with or without a distinct and often crowded granulation. Some diminution in the size of the tubercles and of the number of vertical rows may occur dorsally.

Peristome moderate, nearly flush or incurved, decagonal, with large branchial incisions, having a raised edge. Jaws well developed, with a large foramen, without epiphyses; teeth grooved; perignathic girdle continuous. Spines variable in size, short, or longer than the diameter of the test, striated longitudinally, finely tapering, cylindrical pointed (solid, and this condition is due to fossilization).

Fossil. Lias, Oolites, Cretaceous: England, Europe, N. Africa, Egypt, Asia, N. America; probably Eocene, Europe (*Hebertia*).

The alliance of *Microdiadema, Diademopsis, Hemipedina,* and *Echinodiadema* (Cott.) with the old genus *Pseudodiadema* is evident. The imperforation and non-crenulation, or the reverse conditions, of primary tubercles are insufficient to define and limit genera. Now all these "genera" are placed as subgenera with *Pseudodiadema,* which is synonymous with *Diadema.*

Subgenus MICRODIADEMA, *Cotteau,* 1863 (genus), *Rev. et Mag. de Zool.* sér. 2, vol. xv. p. 225.

Test small, swollen and hemispherical abactinally, re-entering actinally.

Apical system solid, narrow, projecting, granular.

Ambulacra with the pairs of pores in simple vertical series; arrangement of plates "diadematoid." Interporiferous areas with small, almost uniform, perforate and crenulate, scrobiculate primary tubercles in several vertical rows.

Interradia with primary tubercles resembling those of the ambulacra in several vertical rows.

Peristome large, subcircular or decagonal, with well-developed branchial incisions.

Fossil. Lias: Europe.

Subgenus DIADEMOPSIS, *Desor,* 1858 (genus), *Synopsis,* p. 79. *Cotteau,* 1864, *Rev. et Mag. de Zool.* sér. 2, vol. xvi. p. 212.

Test moderate and small, depressed, but subconical above the tumid ambital outline. Coronal plates low and numerous.

Apical system large; madreporite and the basals large; radial plates between the basals, but excluded from the periproct.

Ambulacra narrow, with very small perforate and plain primary tubercles in two rows; pairs of pores in simple vertical series, rarely, but sometimes, crowded at the peristome; plates low, simple primaries near the apical system, and compound elsewhere; the adoral constituent a small primary with its aboral suture convex; the median plate a large primary, and the aboral plate a low primary with the adoral suture convex (diadematoid).

Interradia with four vertical rows of small perforate, plain, primary tubercles, without scrobicules, rather larger than those of the ambulacra; the outer vertical rows reach up furthest abactinally, and hence a granular median area.

Peristome large, branchial grooves moderate. Spines longer than the diameter of the test, very delicate and slender, sharp, striated longitudinally, solid.

Fossil. Infra-Lias and Lias: England and Europe.

Étallon remarked long since upon the slight value of the genus *Hemipedina* and noticed that crenulation of the tubercles is sometimes visible on some portions of a test. Hence the plain condition is in this, as in other groups of forms, not of generic value. It is not possible to separate *Hemipedina* from *Diadema* generically, but the species formerly associated with it form a somewhat natural series, and may enter a subgenus.

Subgenus HEMIPEDINA, *Wright*, 1855 (genus), *Pal. Soc. Monogr.*, *Ech. Foss. Oolit. Form.* p. 143. *A. Agassiz*, 1872–74, *Revision*, p. 291. *Duncan*, 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 42. *Döderlein*, 1886, *Wiegm. Archiv*, Heft i. p. 96.

Test moderate in size or small, circular or slightly pentagonal at the tumid ambitus, flat actinally, depressed, tumid, or subconical dorsally. Coronal plates numerous.

Apical disk large, with large united basal plates.

Ambulacra narrow, straight; pairs of pores in straight series or in arcs of three; simple primary plates near the apex, compound plates elsewhere as in *Diadema*; tubercles in two vertical rows perforate and not crenulate; secondary tubercles exist and granules.

Interradia large, and with from two to six vertical rows of small primary tubercles, but larger than those of the ambulacra, only the outer rows reach the apex, perforate, and some may be crenulated. Median area often bare or granular near the apex; secondary tubercles form rows near the ambulacra.

Peristome moderate, decagonal, and with rather deep branchial incisions; ten buccal plates upon the peristomial membrane. Spines long and slender, needle-shaped, longitudinally striated.

Fossil. Lias and Oolites: England, Europe. Cretaceous: Europe.

Recent. Caribbean Sea, 138–270 fms.; Sigambai, Japan.

Subgenus ECHINODIADEMA, *Cotteau*, 1869 (genus), *Rev. et Mag. de Zool.* sér. 2, vol. xxi. p. 238, pl. xli. (*non Verrill*).

Test small, subconical. Ambulacra with undulating or straight poriferous zones; three pairs of pores directly superimposed to a compound plate, forming arcs actinally; arrangement "diadematoid." Ambulacral and interradial tubercles nearly equal, plain, most numerous and largest actinally; each interradial tubercle corresponding to a swelling of a plate. Granulation distinct and distant, considerable.

Peristome large, subcircular, with branchial incisions.

Fossil. Oolite: Europe.

Genus PLACODIADEMA, *Duncan.*

Syn. *Plesiodiadema*, Dunc. (non Pomel), 1885, Quart. Journ. Geol. Soc. vol. xli. p. 433, fig. viii. De Loriol, 1887, Faune Crét. du Portugal, Éch. fasc. i. p. 31.

Test of moderate size, depressed, circular in marginal outline, tumid dorsally and flatter actinally.

Apical system small, compact, the five basal plates and five radial plates all perforated.

Ambulacra moderately broad, the poriferous zones with numerous pairs of pores in simple vertical series or somewhat arched; plates high, compound, made up of from four to six component primary plates, the sutures curved, with their convexities towards the centres of the plates, the second component from the adoral suture of the compound plate being the largest primary component; a pair of pores to a component plate. Interporiferous areas with two vertical rows of small primary tubercles, perforate and crenulate.

Interradia wider than the ambulacra, with two or more rows of primary tubercles, resembling those of the ambulacra. Peristome decagonal, moderate, and with branchial incisions. Spines striated, moderately long, hollow (see specimen in Brit. Mus.).

Fossil. Oolite: Europe. Cretaceous: England and Europe.

Genus HETERODIADEMA, *Cotteau*, 1862, *Rev. et Mag. de Zool.* sér. 2, vol. xiv. p. 200. *De Loriol*, 1887, *Faune Crét. du Portug.*, *Éch.* fasc. i. p. 44. (See *Pseudodiadema* (*Heterodiadema*) *Pseudo-Bourgeti*, Cott. Pal. Franç., Terr. Crét. vol. vii. pl. 1097.) (*Amended.*)

Syn. *Loriolia*, Neumayr, 1881, Zeits. d. deutsch. geol. Gesellsch. Bd. xxxiii. p. 571; *Colpotiara*, Pomel.

Test moderate, circular in tumid ambital outline, subconical, swollen but depressed abactinally, convex and rarely flat actinally.

Apical system long, and when absent leaving a large scar which intrudes a considerable distance into the depressed posterior interradium. When present, the madreporite is large and passes from the right anterior basal plate to the centre of the system and pushes backwards the periproct, which is bounded by the postero-lateral basal plates and the postero-lateral radial plates and one or two interradial plates. Moreover, the antero-lateral radial plates separate the pairs of basal plates, and either touch the madreporite, or come into the periproctal ring; fifth basal plate absent.

Ambulacra with straight, narrow poriferous zones; the pairs of pores in simple series, except actinally, where there is some doubling; plates compound (diadematoid). Tubercles of both areas in vertical rows, moderate in size, very equal, perforate and crenulated. Peristome flush, decagonal, with branchial incisions.

Fossil. Cretaceous: Europe, N. Africa, Asia (Syria).

Genus CODIOPSIS, *Agassiz*, 1840, *Cat. Syst. Ectyp. Ech. Foss.* p. 19. *Desor*, 1858, *Synopsis*, p. 112. *De Loriol*, 1887, *Faune Crét. du Portug.*, *Éch.* fasc. i. p. 57, pl. ix. (*Amended.*)

Test moderate, swollen, high, often nearly globular, circular or pentagonal in marginal outline; coronal plates numerous, high.

Apical system small, solid.

Ambulacra straight, narrow; pairs of pores uniserial, in very slight arcs; the plates low primaries, but near the peristome they are compound, the middle component a large primary, and the aboral and adoral components demi-plates. Primary tubercles of both areas small, smooth, nearly equal in size, and only occurring actinally and for a short distance towards the ambitus, a granulation being elsewhere. Peristome pentagonal, small, with slight branchial incisions.

Desor states that the primary tubercles are perforate, but they are not so in available specimens.

Fossil. Cretaceous: Europe, N. Africa, Egypt.

Genus Pleurodiadema, *De Loriol*, 1870, *Éch. Helv. Jura*, p. 196; *and* 1885, *Mém. Soc. Pal. Suisse, Genève*, p. 18.

Test of moderate size, more or less swollen above and flat below.

Apical system well developed, flush, compact.

Ambulacra narrow at the apex, with some projecting, imperforate, smooth or slightly crenulate tubercles on the actinal surface only, the rest granular. Poriferous zones straight; pairs of pores in simple series, directly superimposed and separated by small horizontal costæ, which are raised, distinct and stout, especially actinally, and are prolonged to the interradial tubercles.

Interradia actinally and at the ambitus with two rows of wide-apart, projecting tubercles with large mamelons, without scrobicules, and imperforate, slightly crenulate. Very small tubercles abactinally, secondary tubercles absent.

Peristome decagonal, with everted edges; branchial cuts small.

Fossil. Jurassic: Europe.

Genus Magnosia, *Michelin*, 1853, *Rev. et Mag. de Zool.* sér. 2, vol. v. p. 34. *Desor*, 1858, *Synopsis*, p. 115. *De Loriol*, 1887, *Faune Crét. du Portug., Éch.* fasc. i. p. 59.

Test small or moderate, circular at the tumid ambital outline, subhemispherical dorsally, or depressed, concave actinally. Coronal plates numerous, low.

Apical system small; periproct small.

Ambulacra narrow except actinally, where they are broad; pairs of pores in simple straight series, barely in slight arcs of triplets, but near the peristome they become close and polyserial. Plates compound. Interporiferous areas with from two to six or more oblique rows of very small plain primary tubercles.

Interradia with a median depression, abactinally, which is smooth; from four to nine horizontal or oblique rows of very small tubercles resembling those of the ambulacra, diminishing in number abactinally.

Peristome very large, pentagonal, well incised, the ambulacral lips the largest.

Fossil. Oolite: England and Europe. Cretaceous: Europe and N. Africa.

The Liassic species described by M. Cotteau cannot well enter, and, as he suggests, should be removed.

Genus COTTALDIA, *Desor*, 1858, *Synopsis*, p. 113.

Test thin, small or moderate in size, tumid, subhemispherical or subconical, slightly depressed, circular or subpolygonal in ambital outline, flat and slightly tumid actinally.

Apical system small, one or both of the posterior radial plates may enter the periproctal ring. Coronal interradial plates very numerous, low and broad.

Ambulacra narrow; the poriferous zones narrow, slightly sunken, straight, the pairs of pores in simple vertical succession, slightly in arcs actinally; plates compound, there being three low primaries in each, with almost straight sutures. Interporiferous areas slightly tumid, crowded with very small perforate non-crenulate tubercles in horizontal rows, with or without order, and large granules.

Interradia wide, the low plates with very numerous tubercles resembling those of the ambulacra, placed in a horizontal row on each plate, and with granules nearer the transverse sutures.

Peristome sunken, small; the branchial incisions small; the interradial lips the largest.

Fossil. Cretaceous: England, Europe, and N. Africa.

Recent. —— ?

A. Agassiz admits his *Cottaldia Forbesiana* ('Challenger' Report, p. 182) into the genus with much reservation; and I agree with him that the generic position is doubtful. *Cottaldia Carteri*, Dunc., from the Cretaceous of Ras Fartak, Arabia, must enter the genus *Orthopsis*.

II. Subfamily *Diplopodiinæ* (p. 59).

Genus DIPLOPODIA, *McCoy*, 1848, *Ann. & Mag. Nat. Hist.* ser. 2, vol. ii. p. 412. *Desor*, 1858, *Synopsis*, p. 75. *Duncan*, 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 443. *De Loriol*, 1887, *Faune Crét. du Portug.*, *Éch.* fasc. i. p. 33.

Test moderate, depressed, circular in tumid ambital outline.

Ambulacra narrow, with two vertical rows of primary tubercles, perforate and crenulate, smaller or nearly equal in size to the interradial tubercles; pairs of pores in double vertical series near the apex and peristome, and uniserial at the ambitus; there is much crowding out of the poriferous plates in the biserial parts; at the ambitus there are four primary components to a compound plate, or the lowest component may be a demi-plate, the second

primary from the adoral suture of the compound plate is the largest component.

Interradia with two or more vertical rows of primary tubercles, which are large and otherwise similar to those of the ambulacra.

Peristome with well-marked branchial incisions.

Fossil. Oolite: Europe. Cretaceous: England, Europe, Asia, N. Africa.

Diplopodia is very interesting in the construction of the ambulacral plates, which, when compound, are "diadematoid;" on the other hand, *Pedinopsis*, according to De Loriol, has the middle plates of its compounds formed upon the "*Echinus*" type first described by J. Müller.

Genus PEDINOPSIS, *Cotteau*, 1863, *Ech. Foss. de Pyrén.*, *Extr. de Congr. Sci. de France*, 28 *Sess. Bordeaux*, p. 16; 1879, *Éch. Foss. de l'Algér.* fasc. 5, p. 207 (P. Desori). *De Loriol*, 1887, *Faune Crét. du Port.*, *Éch.* fasc. i. p. 53, pl. x. figs. 7, *a*, *b*.

Test moderate, thin, tumid, subconical, flat actinally.

Ambulacra moderately wide; pairs of pores biserial throughout, or polyserial at the peristome, or uniserial at the ambitus; interporiferous area with two or more vertical rows of small perforate and crenulate primary tubercles; the compound plates high, numerous, and the middle plate of each arranged with the others upon the "*Echinus*" type.

Interradial areas with numerous plates not much higher than the compound ambulacral plates, with several or numerous rows of small distant primary tubercles, resembling those of the ambulacra and diminishing in number abactinally.

Peristome with feeble branchial incisions.

Fossil. Cretaceous: England, Europe, N. Africa.

Genus ACANTHECHINUS, *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pt. ii. p. 34, pl. viii.

Test turban-shaped, flat actinally.

Ambulacra convex from side to side, one half of the breadth of the interradia, with two vertical rows of primary tubercles; pores in numerous pairs, diplopodous apically, in single series actinally, very numerous, close, from five to eight pairs to a compound plate; zone narrowest actinally, slanting from the interporiferous

areas. Every compound plate has not a tubercle, for smaller wedge-shaped compound plates intervene between those with tubercles.

Interradia with sunken median areas; plates distinctly sutured and high. Primary tubercles of both areas well developed, some on raised areolæ, all with a broad-based conical boss, largely crenulated, with ridges passing down their tall flanks, and a small imperforate mamelon. Secondary tubercles and granules sharply pointed and spiny.

The apical system and peristome of the species of this interesting group are lost.

Fossil. Eocene: Asia, W. Sind.

The place of this genus must be provisionally with the Diadematidæ.

Genus PHYMECHINUS, *Desor*, 1858, *Synopsis*, p. 133, pl. xvii. *bis.*

Test rather large, tumid in marginal outline, subhemispherical, and depressed abactinally, broad, flat, and slightly tumid actinally. Coronal plates numerous.

Apical system small; madreporite large; basals unequal, some radial plates entering the periproctal ring.

Ambulacra straight, rather broad, especially actinally; pairs of pores diplopodous, close vertically, crowded at the peristome; plates compound, with at least five pairs of pores. Interporiferous areas with two vertical rows of large, projecting, plain, imperforate primary tubercles, with many surrounding granules, extending from the peristome to the apex.

Interradia broad, with two very prominent vertical rows of primary tubercles, resembling in structure those of the ambulacra, but larger, with four rows of small secondary tubercles, extending nearly to the peristome and diminishing above the ambitus.

Peristome very large, decagonal, with very decided branchial incisions; interradial lips small.

Fossil. Oolite: Europe.

Genus ASTEROPSIS, *Cotteau*, 1883, *Bull. Soc. Zool. de France*, sér. 2, vol. viii. p. 450.

Test of moderate size, circular in ambital outline, swollen

above, depressed and subpulvinate actinally. Apical system wanting, large.

Ambulacra with two vertical rows of small, imperforate, crenulate, primary tubercles; poriferous zones straight, the pairs biserial to below the ambitus, in barely oblique triple combinations, not increasing near the peristome.

Interradia with abactinal bare median areas, broad, with two vertical rows of small distant primary tubercles resembling the ambulacral, with large bosses and small mamelons, all diminishing abactinally, scrobiculate; small crenulated secondaries between the primaries and the poriferous zones; granules abundant around the tubercles.

Peristome sunken, subcircular. Spines slender, elongate, cylindrical, marked throughout with granular costæ, which are regularly placed; the ring is crenulated.

Fossil. Upper Cretaceous: Europe.

Genus DIPLOTAGMA, *Schlüter*, 1871, *Zeitsch. f. d. ges. Naturw.* (*Giebel*), n. F., Bd. iv. p. 339. *Zittel*, 1879, *Palæontol.* Bd. i. Lief. iii. p. 509.

Test thick, high, conical, spheroidal.

Apical system small, with a narrow ring.

Ambulacra broad; pairs of pores biserial, and with from five to eight pairs to each tubercle-bearing plate; plates compound. Tubercles similar in both areas, plain, numerous.

Peristome small, central; branchial incisions small.

Fossil. Cretaceous: Europe.

Genus MICROPYGA, *A. Agassiz*, 1879, *Proc. Amer. Acad.* vol. xiv. p. 200; *Report on 'Challenger' Echini*, 1881, p. 67. *Duncan*, 1885, *Journ. Linn. Soc. (Zool.)*, vol. xix. p. 110, pl. 5. fig. 11.

Test large, thin, flat actinally, with a rather sharp circular or subpentagonal ambitus, arched upwards towards the low flattened abactinal surface, broader than high.

Apical system central, with a small periproct, its membrane with small plates, with miliaries; anal opening minute. Basals uniform, largely perforate, angular towards the interradia. Madreporite in the usual basal. Radial plates all entering the narrow periproctal ring, concave at the distal edge where the pore is situate.

Ambulacra narrow, with two vertical rows of perforate, plain, primary tubercles; the poriferous zones with diplopodous pairs, which are numerous, close vertically, distant horizontally, and regular. Plates numerous, low, broad, composed above the ambitus, as elsewhere, of three small plates; the adoral and aboral are low broad demi-plates and the middle plate is a primary which carries the tubercle and occupies the median suture. Pairs of pores of a compound plate really in low broad triplets; only every alternate compound plate has the adoral pair of pores nearest to the ambulacral median line.

Interradia with many low broad plates, with many vertical rows of perforate primaries slightly larger than those of the ambulacra, ceasing at the ambitus, and largest there; and two rows extend vertically to the apex.

Peristome moderate, star-shaped, with broad projecting ambulacral ends, having a well-marked branchial incision and a tag on either side, the interradial margins being more pointed and narrower than those of the ambulacra. Peristomial membrane with imbricating plates.

Jaws and teeth "diadematoid." Spines short, slender, and striated above the ambitus, slender and blunt club-shaped actinally.

Recent. Philippines, Fiji Islands; 100–600 fathoms.

Genus PLISTOPHYMA, *Péron & Gauthier*, 1881, *Éch. Foss. de l'Algér.* fasc. 8, p. 176, pl. xx.

Test moderate, circular at the tumid ambitus, very depressed, nearly three times as broad as high.

Apical system large and subpentagonal.

Ambulacra narrow, straight, with two vertical rows of imperforate plain primary tubercles. Poriferous zones with the pairs of pores biserial, actinally and dorsally, and in simple series at the ambitus.

Interradia broad at the ambitus, the median area distinct and bare abactinally; four or five vertical rows of primary tubercles in each (or more); tubercles resembling those of the ambulacra, those next to the median suture the largest and passing up to the apex, rows oblique; plates numerous, low, broad, and oblique, especially at the ambitus.

Peristome large, pentagonal; branchial incisions small.

Fossil. Cretaceous: Europe and N. Africa.

Cotteau, 1882, Bull. Soc. Géol. de France, sér. 3, vol. x. p. 346, considers the genus to be close to *Magnosia*, and that there is a species at Martigues; but the structure of the apical system and of the poriferous zones forms a decided distinction.

III. Subfamily *Pedininæ* (p. 59).

Genus PEDINA, *Agassiz*, 1840, *Éch. Foss. de la Suisse*, p. 33. *Wright*, 1855, *Pal. Soc.*, *Ech. Ool. Form.* p. 171. *Duncan*, 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 433.

Test large and moderate, thin, circular or slightly pentangular in tumid ambital outline, depressed.

Apical system small, with nearly equal basal plates and small excluded radial plates; periproct moderate.

Ambulacra narrow; poriferous zones wide; pairs of pores in oblique triserial ranks, really in exceedingly arched triplets. Plates low, crowded, and consisting of three components, each with a pair of pores, the pair nearest the median ambulacral line being in the adoral plate, which is either a long low primary plate or a demi-plate, with its aboral suture convex towards the middle component; the middle plate of the three is the largest, is a primary, and its pair of pores is nearest the interradio-ambulacral suture; the aboral plate is either a low primary or a demi-plate, and its adoral suture is convex towards the middle plate, its pair of pores is further from the suture between the interradium and ambulacrum than the pair of the middle plate. Tubercles in two vertical rows; and they are small perforate primaries.

Interradia broad, and with two vertical rows of small primary tubercles resembling those of the ambulacra, extending from peristome to apex, and two or four rows of secondary tubercles, which cease at or above the ambitus.

Peristome small and with branchial incisions.

Fossil. Oolite: England; Europe.

Subgenus PSEUDOPEDINA (genus), *Cotteau*, 1858, *Rev. et Mag. de Zool.* sér. 2, vol. x. p. 221; 1884, *Pal. Franç.*, *Jura*, livr. 66, p. 661, pl. 439.

Test subcircular in marginal outline, depressed or subhemispherical.

Apical system large, granular, flush; basals large, high, extending into the interradia somewhat; radials small; periproct small, pentagonal.

Ambulacra narrow, straight, having distant, large, perforate, non-crenulate primary tubercles on the flat actinal surface and near the ambitus only. Pairs of pores in oblique triplets, the aboral pair being nearest the interradium, and the adoral nearest the median ambulacral line. Plates low, compound, the three components being "diadematoid" primaries.

Interradia with large perforate non-crenulate tubercles diminishing abactinally; plates high and granular.

Peristome large, decagonal; branchial incisions large.

Fossil. Oolite: Europe.

The size of the primary tubercles characterizes this subgenus of *Pedina*.

Genus ECHINOPEDINA, *Cotteau*, 1866, *Rev. et Mag. de Zool.* sér. 2, vol. xviii. p. 362.

Syn. *Echinopsis* (pars).

Test moderate, spheroidal or subspheroidal, flattened above and actinally.

Apical system with a narrow ring and a large madreporite; the posterior radials entering the periproctal ring.

Ambulacra broad and straight, with broad poriferous zones, the pairs in decided arcs of triplets, more or less biserial or triserial; a vertical row of perforated, non-crenulate small primary tubercles close to each poriferous zone; small secondaries or large granules nearer the median line.

Interradia with two vertical rows of small primary tubercles resembling those of the interradia, the broad median space being occupied by rows of granules or small secondaries.

Peristome small, and with branchial incisions fairly developed.

Fossil. Eocene: England and Europe; America, Cuba.

The arched nature of the triplets of the ambulacra distinguishes *Echinopedina* from *Echinopsis*. *Echinopedina Gacheti* of the French Eocene is the type.

Cotteau has described *Echinopedina cubensis* from the Eocene of Cuba (Ann. de la Soc. Géol. de Belg. t. ix. Mémoires, 1881, p. 9, pl. i. figs. 1–6); and it only departs from the generic character by having a second vertical row of small primary and some secondary tubercles. The figure 3 of Cotteau's plate i. shows

ambulacral plates near the ambitus, and fig. 4 above the ambitus; the difference is remarkable. The adoral pair of pores (fig. 4) is nearer the ambulacral median line than the others, as in *Echinothrix*.

Genus STOMECHINUS, *Desor*, 1858, *Synopsis*, p. 124. *Duncan*, 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 435. *De Loriol*, 1887, *Faune Crét. du Port.*, *Éch.* fasc. i. p. 65, pl. x.

Test moderate and large, circular in tumid ambital outline, subconical or subhemispherical dorsally, more or less depressed. Coronal plates numerous.

Apical system with large angular basals forming the periproctal ring, and projecting into the interradia; radial plates small.

Ambulacra moderately wide; at a short distance from the apical system the pairs of pores are in close, oblique, triple series; three pairs to a compound plate, the adoral pair nearest the interporiferous area. A compound plate consists of an adoral and aboral low primary component, the sutures being convex towards the tubercle, and a large median primary carrying the greater part of the tubercle and forming the median sutural angle (diadematoid). Interporiferous areas with non-crenulate imperforate primary tubercles arranged in two vertical rows, with or without additional rows in the median part.

Interradia with a primary tubercle on each coronal plate, similar to, or larger than, the ambulacral tubercles, imperforate and non-crenulate, thus forming two main vertical rows; a varying number of small secondary tubercles and granules on either side of the primary tubercles; median area may be bare near the apex.

Peristome large, pentagonal; branchial grooves large, with raised rims; ambulacral margins much larger than the interradial. Spines small, short, blunt, striated longitudinally.

Fossil. Oolite: England and Europe; America, South. Cretaceous: Europe.

M. de Loriol's species *S. camarensis* (*op. cit.* p. 65) is abnormal; for nothing can be clearer than the "diadematoid" nature of the ambulacral plates of the British types. The narrowness of the ambulacra of the peristome, the small branchial incisions, and the demi-plates of the ambulacra characterize M. de Loriol's species, but do not bring it within our idea of *Stomechinus*.

Genus MICROPEDINA, *Cotteau*, 1866, *Pal. Franç.*, *Terr. Crét.* vol. vii. p. 822, pl. 1197. fig. 8. *Stoliczka*, 1873, *Cret. Fauna of S. India*, vol. iv. 3 ser. viii. 3. *Echin.* p. 41, pl. vi. *De Loriol*, 1887, *Faune Crét. du Port.*, *Éch.* fasc. i. p. 61, pl. x.

Test of moderate size, circular in tumid ambital outline, spheroidal, depressed actinally, or generally depressed.

Apical system small.

Ambulacra straight, slightly prominent; pairs of pores flush, in a narrow zone, either in straight or oblique series of triplets, the adoral pair being remotest from the interradium, and the aboral close to it. Plates low, composed of a low, broad, median primary component, and of adoral and aboral demi-plates, or the adoral may be a primary, the sutures convex towards the tubercles. Interporiferous area with several vertical rows of very small perforate, smooth, primary tubercles, most not reaching the apex.

Interradia with numerous low, broad, coronal plates, with very numerous vertical rows of primaries resembling those of the ambulacra, some of the plates with oblique rows. Rarely more than two vertical rows reach the apex.

Peristome small, circular; branchial incisions small.

Fossil. Cretaceous: Europe, N. Africa, S. India, Asia.

The next genus is represented by a very fine species in the Inferior Oolite of France, *Heterocidaris Trigeri*, Cotteau, and by a small fragment of a probably second species, *H. wickense*, Wright, from the Inferior Oolite of Yorkshire. But although Cotteau had the advantage of examining a fine specimen which was admirably drawn by Humbert, Wright, under unfavourable circumstances, placed the species in their proper family, and noted the affinities with *Astropyga* of the recent fauna. Following Wright, I am able to confirm his judgment in some points, after an examination of the structures of the ambulacra and peristome. Cotteau placed the genus amongst the Cidaridæ, and distinguished it from any of the Diadematidæ. This is to be regretted because really so much of our knowledge about the form is derived from his excellent work and Humbert's masterly drawing. Wright missed the points which I would press upon the distinguished French Echinodermatist, and considered that the narrowness of the ambulacra and width of the

interradia and their numerous tubercles allied the forms sufficiently with Diadematidæ and removed them from Cidaridæ.

I would point out that in Humbert's figure (Cotteau, Ech. de la Sarthe, Suppl. p. 338, pl. lvi. figs. 1–4) the outline of the margin of the peristome is decagonal, the ambulacral borders being very narrow and it is clear that there is a decided branchial cut on either side of the peristomial end of the best preserved ambulacrum. Moreover, there are indications, in the drawing of the peristome, that the perignathic girdle is not after the simple Cidaroid type. The statement of M. Cotteau that the pairs of pores form arcs near the peristome is strictly true, and the figure given by Humbert of the component plates of three compound poriferous plates and parts of an upper and lower one on fig. 4 are conclusive in respect of Cotteau's exactitude. If the upper pair of pores of the fig. 4, pl. lvi. (Cott. *op. cit.*), be removed and the lowest also (they belong to defective compound plates), it will be evident that three sets of triplets remain, and that each set is in a compound plate made up of three smaller plates, and that the middle one of each carries the tubercle. The thin lines indicate the sutures between the component plates of each compound plate; and it will be observed that the middle plate of each is the largest, occupies much of the plate at the tubercle end, which is near the median suture of the ambulacrum, and that its pair of pores is nearer the ambulacro-interradial suture than the other pairs of pores. Then it can be noticed that the adoral suture of the upper pore-bearing plate, in every compound plate, is slightly curved convexity adorally, and that it reaches the median ambulacral sutural line just above the base of the tubercle. The component plate is thus a low primary, and its pair of pores is placed remote from the ambulacro-interradial suture. On the other hand, the aboral suture of the lowest of the pore-bearing plates of each series has its convexity directed aborally, and it may noticed that the end of the suture is either at the median line or falls short. In this last instance the plate is a demi-plate; but in either case the pair of pores is situated normally, that is, remote from the ambulacro-interradial suture. Now this arrangement of the plates composing a component ambulacral tubercle-bearing plate is essentially "diadematoid," and is most distinct from that of any Cidaroid. (Duncan, Anat. Amb. Recent Diadematidæ, Journ. Linn. Soc. (Zool.), vol. xix. p. 96, 1885.)

The arrangement is represented in the recent forms of *Echinothrix*, to which genus the alliance is greater than to *Astropyga*. But other distinctions of structure between the genera are evident.

The fossil form has not the ambulacra with the width and convexity of those of *Echinothrix*, and the median interradial area near the apical system is tuberculate in *Heterocidaris*.

Genus Heterocidaris, *Cotteau*, 1860, *Bull. Soc. Géol. de France*, sér. 2, vol. xvii. p. 378; *Éch. Foss. de la Sarthe, Suppl.* p. 338, pl. lvi. *Wright*, 1860, *Pal. Soc., Ech. Ool. Form.* p. 456. (*Amended.*)

Test large, circular in outline at the tumid ambitus, broader than high, flat actinally, subconvex abactinally.

Apical system absent in the specimens.

Ambulacra very narrow, straight, not projecting, with two vertical rows of very small perforate and crenulate tubercles. Poriferous zones slightly depressed, narrow; pairs of pores in almost straight series at and above the ambitus, although in triple compound plates; near the peristome the pairs of pores are in arcs and oblique; the tubercle of a compound plate is on the middle component plate, and the sutures of the adoral and aboral component plates and the middle plate are curved more or less, their convexities directed towards the middle plate. Usually the components are low, broad primaries; but a demi-plate may occur near the actinosome.

Interradia very broad and tumid; the plates low and broad, carrying several rows of large, perforate, crenulate and scrobiculate primary tubercles separated by a rich granulation. The vertical rows diminish above the ambitus; but at least four reach close to the apical system, especially the pair close to the ambulacra, so that the median vacant space is very small and insignificant.

Peristome small, decagonal; ambulacral ends small, with branchial incisions on their flanks. Spines long, cylindrical, striated longitudinally.

Fossil. Inferior Oolite: England, Europe.

M. Cotteau states that the auricular processes must have been strong.

Genus ECHINOTHRIX, *Peters*, 1853, *Abh. k. Akad. Wiss. Berlin*, (1854), p. 114. *A. Agassiz*, 1872–4, *Revision*, p. 413. *Duncan*, 1885, *Journ. Linn. Soc.* (*Zool.*), vol. xix. pp. 101 and 202. *Lovén*, 1887, *Ech. desc. by Linnæus*, p. 137. (*Amended.*)

Syn. *Garelia*, Gray; *Savignia*, Desor.

Test large, thin, tumid, moderately high, depressed, broad.

Apical system large, more or less sunken; basals large and projecting into the interradial spaces; radials small and entering the ring; the periproct large, with a close pavement of plates. Coronal plates numerous.

Ambulacra tumid, narrow, with several vertical rows of very small tubercles, which are crenulate and perforated, diminishing in number actinally; plates numerous, low, broad, composed of three primaries, with the sutures convex towards the tubercle; near the peristome the adoral component is small and excluded from the interradial suture. Pairs of pores large, in close arcs, the adoral pair nearest the ambulacral median line, forming, with others, a vertical series.

Interradia with a bare median space, sunken, elsewhere several vertical rows of large primary tubercles, crenulated and perforated, scrobiculate, diminishing in number abactinally.

Peristome large, with deep branchial incisions and tags; membrane with small plates. Perignathic girdle with very broad, low ridges; processes expanded above, opening large. Jaws with the foramen of the pyramid an open arch, the teeth grooved. Spines slender, long, striated, verticillate, more or less solid.

Recent. E. coast of Africa, Pacific Islands, Japan, Philippines, E. Indian Islands, Red Sea.

Genus ASTROPYGA, *Gray*, 1825, *Ann. Phil.* vol. xxvi. p. 246. *Peters*, 1853, *Abh. k. Akad. Wiss. Berlin* (1854), p. 110. *A. Agassiz*, 1872–4, *Revision*, p. 417; 1881, *Report on 'Challenger' Echini*, p. 72, pl. x. *a.* fig. 9. *Duncan*, 1885, *Journ. Linn. Soc.* (*Zool.*), vol. xix. p. 106, pl. v. (*Amended.*)

Test large, tumid at the ambitus, depressed, thin, more or less flexible; ambulacra bulging.

Apical system large; basals large, triangular, elongate; radials much smaller, narrow, and entering the periproctal ring. Membrane with circular rows of plates.

Ambulacra narrow, convex, with two vertical rows of large,

crenulate and perforate primary tubercles; poriferous zones broad; plates compound, large, high, composed at the ambitus and actinally of two sets of triplets, each consisting of low, broad primaries, sometimes with a demi-plate, with their sutures curved, convexity towards the tubercles; pairs of pores in oblique sets of three pairs, really in close triplets, the adoral pair of a compound plate being nearest the ambulacral median line and the aboral the most remote.

Interradia with a broad median area abactinally, elsewhere with several rows of crenulate and perforate primaries, slightly larger than those of the ambulacra, each with a large flat scrobicule. Coronal plates rather numerous, low and broad, overlapping more or less, pitted inside and some split longitudinally or not.

Peristome variable in size; branchial cuts large; membrane with plates, the largest carrying spines. Jaws small; teeth grooved. Larger spines about one half of the diameter of the test, striated, verticillate.

Recent. Panama, Gulf of California, Zanzibar, Philippines, East-Indian Islands.

Genus POLYCYPHUS, *Agassiz*, 1846, *Cat. Rais. des Éch.*, *Ann. d. Sci. Nat.* sér. 3, vol. vi. p. 361. *Desor*, 1858, *Synopsis*, p. 117. *Cotteau*, 1863, *Rev. et Mag. de Zool.* sér. 2, vol. xv. p. 261.

Test small, subconical or hemispherical dorsally, tumid at the circular ambitus, rather flat actinally.

Apical system small; basal plates large and united; periproct oblique or not.

Ambulacra straight, rather wide, with rather broad poriferous zones, which may be sunken; pairs of pores in close and very oblique triplets, triserial abactinally and polyserial actinally; plates low, compound, "diadematoid." Tubercles of the interporiferous areas small, plain, in four or more vertical rows, the outer the larger.

Interradia with numerous low broad plates, each with two horizontal rows of numerous plain tubercles, resembling those of the ambulacra; but one row has small tubercles; usually the tubercles increase in size actinally; vertical rows five or more in number.

Peristome large, decagonal; ambulacral lips large; branchial incisions well developed.

Fossil. Oolite: England and Europe.

Genus CODECHINUS, *Desor*, 1858, *Synopsis*, p. 111. *Cotteau*, *Pal. Franç.*, *Terr. Crét.* vol. vii. pl. 1198. fig. 6.

Test small, tumid, spheroidal, flattish actinally. Coronal plates high.

Ambulacra broad; poriferous zones broad; pairs of pores triserial, close, in nearly horizontal triplets: plates compound, low, some of three low primaries, "diadematoid"; others with a large middle primary, a low aboral demi-plate, which is broad, and an adoral demi-plate which is excluded from the interradial suture. The middle pair of pores is nearest the interradium. Tubercles very small, plain, distributed irregularly, most numerous and closest actinally, but few elsewhere.

Interradia with the median sutural area rather depressed; tubercles resembling those of the ambulacra, limited to parts of plates remote from the median line of the area, which is naked. A minute granulation separating the tubercles of both areas. Peristome small, central, diagonal.

Fossil. Cretaceous: Europe, N. Africa.

IV. Subfamily *Orthopsinæ* (p. 59).

Genus ORTHOPSIS, *Cotteau*, 1863, *Pal. Franç.*, *Terr. Crét.* vol. vi. p. 550. *Stoliczka*, 1873, *Pal. Ind.*, *Cret. Fauna S. India*, vol. iv. 3. viii. ser. 3, *Echin.* p. 45, pl. vii. *De Loriol*, 1887, *Faune Crét. du Port.*, *Éch.* fasc. i. p. 46, pl. viii.

Test moderate in size or small, depressed, circular or slightly pentagonal in ambital outline, tumid dorsally, flat actinally.

Apical system with five perforated basals; madreporite well developed; radial plates, all or some entering the anal ring, which is variable in outline.

Ambulacra much narrower than the interradia, straight; pairs of pores numerous, in straight series; poriferous zone narrow; plates simple, low, primaries dorsally, but near the ambitus and actinally two primaries may combine, and the suture passes transversely through the interporiferous tubercle. Tubercles of the ambulacra small, perforate, and smooth; two vertical rows.

Interradia with several vertical rows of small primaries resembling those of the ambulacra, or slightly larger, some reaching up dorsally.

Peristome moderate, with well-developed branchial incisions;

perignathic girdle with ridges and processes which unite and form a small arch.

Fossil. Oolite: England, Europe. Cretaceous: Europe, N. Africa, Hindustan. Eocene: Egypt.

De Loriol has shown that *Hemipedina Sæmanni*, Wright, 1855, is an *Orthopsis*.

Genus EODIADEMA, gen. nov.

Test small, thin, circular in tumid marginal outline, subconical dorsally, tumid and re-entering actinally, broader than high.

Apical system moderate in size, ovoid or elliptical in the outline of the periproct; five large basal plates, four in contact and the fifth or posterior separated from its fellows, on either side, by a radial plate.

Ambulacra narrow, straight, wider than the interradia at the peristomial margin, narrower elsewhere; poriferous zones narrow; the pairs of pores numerous, in simple vertical series, barely any crowding near the peristome; plates all low, broad primaries; interporiferous areas rather broad, crowded with blunt granules dorsally, some larger granules near the poriferous zones, and giving place at the ambitus to some very small crenulate and perforate tubercles which diminish actinally.

Interradia broad; plates not numerous, broader than high; two vertical rows of perforate, crenulate and scrobiculate primary tubercles in each area, a few large at the ambitus and becoming rapidly very small dorsally, or replaced by distinct, large, crowded granulation, diminishing also actinally. Scrobicules large at the ambitus, and usually coalescing. A large, blunt, very marked granulation occurs beyond the scrobicules on each plate, and also on all the plates up to the apex, except at an angular space contiguous with each basal plate, and extending downwards, variously, along each median line, where there are no granules, but a plain surface. Peristomial edge small and pointed.

Peristome sunken, decagonal, small, and with well-marked branchial incisions.

Fossil. Middle Lias: England.

This is a most interesting genus; and the species *Eodiadema granulata* was discovered by E. Wilson, Esq., F.G.S., of the Bristol Museum. The alliance is very close to the Orthopsidæ, although

they have smooth tubercles as a rule. It is the single primary plates of the ambulacra without any compound ones, coupled with the small tubercles of the ambulacra and the few large primaries near the ambitus, all the rest of the test being granular, that separate the type from *Hypodiadema* and *Hemicidaris* and *Diadema*. It is very interesting to find such a simple form so low down in the Mesozoic series, and it may well have been the precursor of the genera just mentioned. The similarity of the genus to *Acrosalenia* is striking; but there is evidence that the sur-anal plates were not present.

If more was known about *Hypodiadema*, the alliance of the new genus with the oldest Mesozoic forms would be very definite; but the good drawings of Desor and other describers show that the interradia of the genera differ considerably.

MM. Péron and Gauthier have described *Cyphosoma Heinzi*, and notice its abnormal nature; and they consider that had it been placed in *Pseudodiadema* it would have been equally erratic. Probably the classificatory position is near *Orthopsis*, for the pairs of pores are in simple, low, primary plates. I have diagnosed a new genus for the form, and dedicate it to M. Péron.

Genus PERONIA, gen. nov.

Syn. *Cyphosoma*, Cotteau, Péron et Gauthier, 1884, Éch. Foss. de l'Algérie (2nd edit. of fasc. 2), p. 96, pl. ix.

Test small, circular in tumid ambital outline, very depressed.

Apical system annular, pentagonal, symmetrical; periproct large, circular; basal plates equal, broad, low, perforated largely; radial plates small, all entering the ring and reaching the periproct, the margin of which is slightly raised.

Ambulacra narrow, with narrow poriferous zones, the pairs not numerous, and in simple vertical series throughout, each in a low primary plate. Interporiferous areas with small granules only.

Interradia broad, with only seven coronal plates on a side, with as many crenulate, imperforate and scrobiculate tubercles, largest at the ambitus, the rest of the plate granular; secondary tubercles absent.

Peristome large, decagonal, the branchial incisions with everted edges.

Fossil. Cretaceous (Neocomian): Algeria.

Cyphosoma Heinzi thus becomes *Peronia Heinzi*, Péron et Gauthier, sp.

Genus Echinopsis, *Agassiz*, 1840, *Catal. Syst. Ectyp. Ech.* p. 18. *Desor*, 1854, *Synopsis*, p. 98 (pars). *De Loriol*, 1881, *Eoc. Ech. aus Ægypt. u. d. Lib. Wüste*, *Palæontographica*, n. F. x. i. (xxx.) p. 10.

Test thin, small or moderate in size, hemispherical, or subconical and tumid abactinally, rather flat actinally.

Apical system narrow, the basals unequal; the radials small and close to the periproct, but not forming its ring. Periproct large.

Ambulacra large, straight, flush with the test; pairs of pores in simple straight series; plates compound, triple, or quadruple, made up of low broad primaries; tubercles very small, close, perforate and non-crenulate, extending the whole length of the ambulacrum in two vertical rows placed near to the poriferous zones.

Interradia with two vertical rows of small primary tubercles, slightly larger than, but otherwise similar to, those of the ambulacra; minute granules surrounding the non-sunken scrobicules. Sutures of the plates distinctly seen.

Peristome small, slightly depressed; branchial incisions slight.

Fossil. Eocene: Europe, Egypt.

Echinopsis Edwardsi, Forbes, of the London Clay, is an *Echinopedina*.

Genus Gymnodiadema, *De Loriol*, 1884, *Recueil Zool. Suisse*, vol. i. No. 4, p. 606.

Test thin, tall, swollen, moderate.

Apical system flush; the madreporite triangular, slightly developed; radial plates small.

Ambulacra narrow; poriferous zones straight, with regularly superimposed pairs of pores in simple series; the plates very numerous, low, narrow primaries; interporiferous areas very narrow, have abactinally very small granules, which are barely visible to the naked eye, yet forming vertical series; they are replaced actinally by very small tubercles with perforate mamelons.

Interradia very broad, covered with granules like shagreen;

near the peristome there are some small tubercles, which are perforate and scrobiculate; they are more developed than those of the ambulacra.

Peristome (wanting) probably small.

Fossil. Oolitic: Europe.

The drawing of the solitary species given by De Loriol shows a globose test longer than broad, and very minutely granular; the increased size of the ornamentation actinally is very characteristic.

Genus incertæ sedis.

Genus PROGONECHINUS, *Duncan and Sladen, Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind,* p. 43, pl. x. figs. 1–4.

Test small, moderately high, subhemispherical, concave actinally; margin circular and tumid.

Apical system absent.

Ambulacra narrow, with straight poriferous zones having numerous pairs of pores directly superposed and close. The plates compound, the adoral component a low broad demi-plate, the middle a large primary plate carrying two small tubercles, and the aboral component a low broad primary; sutures grooved and distinct; tubercles plain, in two vertical series on each side of the median line, others near the ambitus; low granules often forming ridges.

Interradia broad; plates low; two persistent vertical rows of plain scrobiculate primaries larger than those of the ambulacra; at the ambitus two or more vertical rows occur besides, but are lost actinally and dorsally. Large granules with mamelons occur, and a row near each poriferous zone has costæ passing towards the pairs of pores and also to the scrobicules of the neighbouring primary tubercles. Grooves along the upper and lower sutures of the interradial plates near the median line.

Peristome circular; branchial incisions well developed, with thick everted margins.

Fossil. Eocene: Asia.

This is a very synthetic genus, and links the Diadematidæ and the Temnopleuridæ.

V. Family Cyphosomatidæ.

Test moderate in size, circular or subpentagonal in tumid marginal outline, depressed, rarely subconical, highly ornamented; plates moderate in number or numerous.

Apical system very variable in size, shape, and structure, compact, or with some or all radials intervening between the basals, and the posterior basal intruding upon the posterior interradium; with the periproct posterior, and its plates either few or numerous and hexagonal; arms posterior; the madreporite in the right anterior basal.

Ambulacra with high compound plates, with from three to seven pairs of pores in an arc; near the apical system, and extending variously actinally, a biserial arrangement of the pairs, or not; pairs crowded or not at the peristome. The adoral and supra-adoral components are primaries, and the others demiplates. Two vertical rows of primary tubercles. (Duncan, 1885, Amb. Foss. Ech., Quart. Journ. Geol. Soc. p. 447.)

Interradia usually depressed dorsally, with bare median spaces; rows of tubercles variable in number, larger than those of the ambulacra.

Peristome moderate and large, with branchial incisions. Spines long and short, solid, some as needles; striated longitudinally.

This family subdivides with difficulty; and the two groups of it are not of subfamily value.

Division I.
Genus *Cyphosoma*.
Subgenus *Leiosoma*.
Genus *Coptosoma*.
Gauthieria.
Thylechinus.

Division II.
Genus *Micropsis*.
Subgenus *Gagaria*.

Division I.

Species with and without a diplopodous poriferous arrangement cannot be placed in the same genus; and therefore only the diplopodous species remain in the genus *Cyphosoma* as now constituted. Moreover, the genus now includes the species with the apical system encroaching upon the posterior interradium. Cotteau has found the details of the apical system; and

the typical arrangement is seen in *C. Delmarrei*, Pal. Franç., Terr. Crét. vol. vii. pl. 1140; see also *C. Foukanense*, Péron & Gauth. Foss. de l'Algér. fasc. 7, pl. vi. fig. 8.

Genus CYPHOSOMA, *Agassiz*, 1840, *Catal. Syst. Ectyp. Ech.* p. 19. *Desor*, 1858, *Synopsis*, p. 86. *Wright*, 1869, *Pal. Soc.*, *Foss. Cret. Ech.* vol. i. p. 128. *A. Agassiz*, 1873, *Revision*, p. 487. *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 31. *Duncan*, 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 447. *J. Lambert*, 1888, *Bull. Soc. d. Sci. Nat. de l'Yonne*, 1 Semestre.

Syn. *Phymosoma*, Haime.

Test moderate in size, tumid at the circular or slightly polygonal ambitus, swollen but depressed dorsally and actinally, broader than high. Coronal plates few, their sutures distinct superficially.

Apical system large, with five basal plates; the madreporite in the usual plate, and all or some of the radial plates entering the periproctal ring, the posterior basal thrown more or less backwards and intruding upon the posterior interradium.

Ambulacra with well-developed poriferous zones, undulating; pairs of pores diplopodous abactinally, and in arcs of from four to six or more pairs, and more crowded still at the peristome; plates compound, high, formed of an adoral, a supra-adoral, and an aboral primary component, the other plates of the compound being demi-plates; the direction of the sutures of the primary plates of the compound is convex towards and on the boss of a large tubercle, the sutures usually being visible on its flanks. Two vertical rows of primary tubercles.

Interradia large, with two or more vertical rows of primary tubercles equal to or larger than those of the ambulacra and similar in their constitution, being imperforate and crenulate. Secondary tubercles exist, and small tubercles or granules in large numbers, the median areas often bare for some distance from the apical system.

Peristome small or moderate; branchial incisions well marked. Spines solid, long, subcylindrical, aciculate, or spathiform, straight or bent spoon-shaped, striated or smooth; milled head and acetabular cuts distinct.

Fossil. Oolite: Europe. Cretaceous: England, Europe, N. Africa, Asia. Eocene: Asia.

Subgenus LEIOSOMA, *Cotteau & Triger*, 1859 (genus), *Ech. du Dépt. de la Sarthe*, p. 271 ?, pl. xlv.; 1881, *with Péron et Gauthier*, *Ech. Foss. de l'Algér.* pt. 2 of fasc. 8, p. 141, figs. 7–11.

Syn. *Gomphechinus*, Pom.; *Micropeltis*, Pom.

The primary tubercles are plain, and neither crenulate nor perforate. Pairs of pores biserial throughout, or not so at the ambitus; several rows of interradial primary tubercles, or two only.

Fossil. Oolitic: Europe. Cretaceous: Europe and N. Africa.

Genus COPTOSOMA, *Desor*, 1858, *Synopsis*, p. 91. *Duncan & Sladen*, 1882–86, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pp. 116–117, pl. xxii. *Duncan*, 1885, *Quart. Journ. Geol. Soc.* vol. xli. p. 447. *Lambert*, 1888, *Bull. Soc. d. Sci. Nat. de l'Yonne* (extrait), p. 7.

Syn. *Cyphosoma* (pars).

Test moderate, subconical, or depressed dorsally, tumid at the ambitus. Coronal plates few in number.

Apical system flush, intruding somewhat upon the posterior interradial spaces; one or more radial plates may enter the subcircular or deformed periproctal ring; periproct somewhat thrown back.

Ambulacra with uniserial pairs of pores, and in arcs throughout; plates formed of more than three components, uniting after the Cyphosomatoid type.

Interradia with two vertical rows of primary tubercles, crenulated, and with several small secondaries upon each broad and comparatively low plate, larger than or of the same size as the primaries of the ambulacra; sutures may be visible, and the tubercles may be deficient dorsally.

Peristome moderate to large, with branchial incisions.

Fossil. Cretaceous: Europe, N. Africa, N. America. Eocene: Europe and Asia.

Recent. Japan.

The genus differs from *Cyphosoma*; for it is not diplopodous, and the poriferous plates have more than three components. It appears that very probably the recent *Phymosoma*=*Cyphosoma crenulare*, A. Ag., and also De Loriol's *C. Mortoni*, should come

in here. Unfortunately the name of the genus refers to cuts or sutural impressions upon the tubercles; and these are not characters of any importance. The fine Sindian forms of *Cyphosoma macrostoma*, Dunc. & Slad., and *C. undatum*, Dunc. & Slad., are now species of *Coptosoma*. *C. Joudi*, Péron et Gauth., should enter.

The genus *Microsoma*, Cotteau, 1886, Bull. Soc. Zool. de France, vol. xi. p. 715, is so doubtful on account of the bad condition of its specific type, that it is simply recorded.

Genus GAUTHIERIA, *Lambert*, 1888, *Bull. Soc. d. Sci. Nat. de l'Yonne*, 1 Semestre (extrait), p. 7.

Syn. *Cyphosoma* (pars).

Test moderate, subcircular or subpentagonal, moderately tumid.

Apical system largely developed, pentagonal, with the posterior angle extending well into the corresponding interradium; the basal plates unequal; the madreporite in the largest and anterior lateral basal; the other lateral basals more or less hexagonal, and at the angles of the system the posterior basal forming a narrow rim to the posterior angle, and limiting the posteriorly excentric anus; radial plates large, all entering and separating the basals. Periproctal area large, and occupied by seven or more hexagonal plates, forming a closed area anterior to the circular anus.

Spines long, cylindrical, finely striated longitudinally.

Fossil. Cretaceous: England and Europe.

In one solitary instance this remarkable apical system has been preserved and described, thanks to M. Lambert; in all others there is only a large vacant space. The genus includes the former *Cyphosoma radiatum*, Sorginet (*subradiatum*), 1850, and its synonyms *C. simplex* and *C. spatulifera*, Forbes, and *C. perfectum*, Cotteau.

M. Lambert has founded a genus, or rather suggests the recognition of a genus of M. Pomel for *Cyphosoma pulchellum* and *C. Said* and many others.

In agreeing with M. Lambert's intelligent scheme, it is necessary to draw attention to M. Pomel's definition, which contains the statement that the upper part of the "interambulacrales" is more or less depressed "en gouttière" in the males, and hollowed

"en marsupium" in the females. This is not quite capable of verification; but it has nevertheless originated the name of a genus, *Thylechinus.*

Genus THYLECHINUS, *Pomel*, 1883, *Thèses, Class. Méth.* p. 91. *Lambert*, 1888, *Extr. Bull. Soc. d. Sci. Nat. de l'Yonne*, p. 11. (*Amended.*)

Syn. *Cyphosoma* (pars), Cott., Pér. et Gauth. 1881, Éch. Foss. de l'Algér. fasc. 8, p. 172, pl. xix. figs. 3–10 (*Cyphosoma Saïd*).

Test with a compact symmetrical apical system; radial plates excluded.

Ambulacral plates having three components and three pairs of pores in simple series only. Pairs of pores uniserial throughout; the interporiferous areas with two vertical rows of crenulated tubercles smaller than those of the interradia.

Interradia with two vertical rows of large primary tubercles crenulated. The median areas more or less depressed dorsally.

Peristome large; lips unequal; branchial incisions slight.

Fossil. Cretaceous: Europe, N. Africa.

For the generic position of *Cyphosoma Heinzi*, Pér. et Gauth., see p. 83.

Division II.

The genus *Micropsis*, Cotteau, 1855–56, was diagnosed so as to include *M. Desori*, which has four vertical rows of ambulacral tubercles, and the pairs of pores in arcs of four; the interradial plates very wide and rather low, with a primary tubercle and three small primaries on one side, and two on the other on each plate. There is no doubling of pairs, and the branchial incisions are small; but the number of coronal plates is great. It is like a *Coptosoma* with a considerable number of coronal plates.

A species, *Micropsis microstoma*, has three vertical rows of tubercles and five or six pairs of pores in arcs, to a plate. Again, *M. Leymerii* has only two pairs of vertical rows of tubercles and three pairs of pores to a plate. All the radial plates enter the apical ring. We do not understand how *M. globosa*, Cott., and *M. leridensis*, Cott., can be associated with the type species in the same genus. The *Micropsis* we described from the Nummulitic of Sind has many of the characters of, but the structure of the ambulacra differs from, M. Cotteau's type.

M. de Loriol (Ours. Tert. de la Suisse, Pal. Soc. Suisse, 1875, vol. ii. p. 16) considers *Micropsis* to be synonymous with the Cyphosomatoids with uniserial pairs of pores (*Coptosoma*); but the height of so many of the tests of *Micropsis*, the considerable number of the coronal plates, and the small size of the primary tubercles are distinctive. Nevertheless it is evident that not only are there species of *Coptosoma* in Cotteau's list of Micropsides, for instance *M. leridensis*, but some require elimination from the family, for instance *M. Vidali*, Cott., which is altogether aberrant.

The ambulacra of the species with four pairs of pores to a compound plate, such as the type species *M. Desori*, have not the component plates of their symmetrical compound plates arranged as in the genera *Cyphosoma* and *Coptosoma*; on the contrary, the arrangement resembles that of the species of *Placodiadema* (p. 64), which have numerous components to an ambulacral plate. The compound plate is high, and is composed of a small, low, broad adoral primary, very low at the median suture of the compound plate; or it may be a demi-plate; next comes a large primary, comprising most of the tubercles and the angle of the median suture; then succeed aborally, two low broad primaries, their adoral sutures being rather curved, convexity adorally. (See Quart. Journ. Geol. Soc. vol. xli. p. 431, fig. 8.) This arrangement may also occur when there are five pairs of pores to a compound plate; and then the last pair of pores is in a low broad primary, which resembles the aboral primaries of the other plate. This kind of arrangement is not seen in any species of *Cyphosoma*; and therefore there is a good physiological difference between the species with numerous pairs of pores and those with few which have been included in *Micropsis* and *Cyphosoma* or *Coptosoma*.

The species with three pairs of pores in an ambulacral plate may be grouped around *Micropsis venustula*, Dunc. & Sladen, 1884, Pal. Ind. ser. xiv., Foss. Ech. Sind, p. 119, pl. xxii. figs. 1–7. The apical system has large basal plates; a radial enters the ring, and the periproct is large and deformed; the amulacra are narrow, and have two vertical rows of small perforate and crenulate primary tubercles and two vertical rows of secondary tubercles; the plates are high and compound; the adoral plate is a large primary carrying the bulk of a tubercle, and the other plates, placed aborally to it, are low broad primaries. The difference

between this arrangement and that already noticed is that in the instance of the plates with more than three pairs of pores the adoral primary is added, as it were, to the compound.

The interradia have only two vertical rows of primary tubercles, very slightly larger than those of the ambulacra; and there are two vertical rows of small secondary tubercles.

Micropsis Leymerii, Cott., and *M. d'Orbignii*, Cott., appear to be associated with this Sindian species in a little group which is hardly worthy of more than a subgeneric title (see *Gagaria*).

A new genus or subgenus is required for *M. Vidali*, Cott.; for as we define the species it is a *Psammechinus* with crenulate tubercles.

Having made these necessary remarks, we proceed to give the diagnosis of *Micropsis*, which is transitional between the Cyphosomatidæ and the Diadematidæ.

Genus MICROPSIS, *Cotteau*, 1855, *Éch. Foss. des Pyrén.*, *Bull. Soc. Géol. de France*, sér. 2, vol. xiii. p. 326; 1882, *Bull. Soc. Zool. de France*, vol. vii. p. 411. *Duncan and Sladen*, 1884, *Pal. Ind.* ser. xiv., *Foss. Ech. of Sind*, p. 119. (*Amended.*)

Test of variable size, circular or slightly polygonal in tumid marginal outline, tumid dorsally, subconical, subhemispherical or depressed, concave actinally.

Apical system flush, with a large periproct, large basals, and one or more of the radial plates may or may not enter the ring. Coronal plates rather numerous.

Ambulacra with small primary tubercles, perforated and crenulated, in two or more vertical rows; pairs of pores from three to five in number; plates compound; the aboral components low and broad, with adoral sutures convex adorally, and the adoral component a large primary carrying the tubercle; a low primary or a demi-plate may or may not form the lowest part of the combination.

Interradia with many or few vertical rows of primary tubercles and secondaries.

Peristome small; branchial incisions well developed. Spines slender, long, subcylindrical, striated longitudinally, sharp.

Fossil. Cretaceous: Europe. Eocene: Europe, Asia, Egypt.

Subgenus GAGARIA, *Duncan*.

Syn. *Micropsis* (pars).

Tests with two vertical rows of primary tubercles in each area,

and with only three pairs of pores in each compound ambulacral plate.

Fossil. Cretaceous: Europe. Eocene: Asia (Sind).

The specific type is *Gagaria* (*Micropsis*) *venustula*, Dunc. & Sladen, 1884, Pal. Ind. ser. xiv., Foss. Ech. W. Sind, pt. iii. p. 119, pl. xxii. figs. 1–7, from the Nummulitic.

M. Lambert, 1888, Bull. Soc. d. Sci. Nat. de l'Yonne (extrait), contains some excellent remarks bearing upon M. Pomel's subdivision of *Cyphosoma*.

VI. Family ARBACIIDÆ, *Gray*. (*Amended.**)

Test moderate in size, subhemispherical or subconical, depressed dorsally, flat actinally; epistroma with granules, projecting ridges, grooves, sessile glassy knobs, elongate or rugose, and tall, especially on the bare dorsal interradial median areas.

Apical system large; the periproct oval and oblique; the periproctal plates four, rarely more, triangular; the radial pores adoral, double.

Ambulacra straight, narrow, expanding near the peristome; pairs of pores simple or in large arcs, or crowded actinally; the plates compound near the ambitus, the middle component a large primary; the adoral and aboral being demi-plates with very curved sutures, their direction being nearly vertical towards the ambulacral median line; or the primary is adoral and the demi-plates are aboral to it.

Interradial plates with several or few vertical series of primary imperforate, non-crenulated tubercles, usually larger than those of the two rows of the ambulacra; with expanded bosses. Tentacles heteropodous. Spheridia solitary or numerous.

Peristome large, incurved at the sides of the ambulacra, and with branchial tags. Teeth keeled. Jaws with the pyramidal foramen open above. Plates united along the vertical sutures by dowelling, some of the projections may be large and lamellar.

Genus *Arbacia*.
Echinocidaris (gen. nov., non auct.).
Cœlopleurus.
Podocidaris.

* For the structures noticed in this definition, see Duncan and Sladen, Journ. Linn. Soc. vol. xix. 1885, pp. 25 *et seq.*; and Lovén, 1887, Ech. descr. by Linnæus, pp. 80 *et seq.*

Genus ARBACIA, *Gray*, 1835, *Proc. Zool. Soc.* p. 58. *Troschel*, 1872, *Arch. f. Naturg.* vol. xxxviii. p. 293; 1872, vol. xxxix. p. 308. *A. Agassiz*, 1874, *Revision*, pp. 263, 399. *Bell*, 1879, *Proc. Zool. Soc.* p. 436. *Duncan & Sladen*, 1885, *Journ. Linn. Soc.* p. 48. *Lovén*, 1887, *Ech. descr. by Linnæus*, p. 80. (*Amended.*)

Syn. *Echinocidaris*, Desmoulins, 1835, Lütken, 1863; *Agarites*, Agassiz, 1841; *Pygomma*, Troschel, 1873.

Test moderate, thick, subcircular at the tumid ambitus, subhemispherical, depressed dorsally, flat actinally.

Apical system large, prominent; basals projecting into the interradia, long; radials entering or not the ring, the pore adoral double; all plates ornamented with epistroma; periproct oval, oblique, with four triangular periproctal plates (sometimes three to five).

Ambulacra straight, narrow to the ambitus and larger there and at the peristome and with a projecting lip; poriferous zones moderately narrow, and the pairs of pores in simple pairs dorsally, then in arcs of three and polyserial at the peristome; plates low primaries dorsally, then compound with a large median plate and an adoral and an aboral demi-plate, their inner sutures nearly vertical and curving upon the tubercle. Tentacles heteropodous.

Interradia with bare median dorsal areas near the apex, elsewhere with from three to seven vertical rows of plain primary tubercles on each side of the median line, more or less oblique, larger than those of the two vertical rows of the ambulacra, all diminishing in number and size dorsally. Epistroma greatly developed. Secondary tubercles absent.

Peristome large, tags or lamellæ for the branchiæ; ten buccal plates. Perignathic girdle with ridges, the ambulacral processes moderate but not arched. Jaws with the foramina of the pyramids open; teeth with a keel. Spines long, moderately stout, some spathiform, cellular within, may have a "cap." Pedicellariæ, some with large glands on their stalks. Plates of the test united at the vertical sutures by partial dowelling, some of it coarse. A solitary spheridium in each ambulacrum in a large pit.

Fossil. N. America, Tertiary? (The European Miocene species is a *Psammechinus.*)

Recent. Florida, Caribbean Sea, Long Island to Yucatan, Brazil, Straits of Magellan, Patagonia, Chili, Peru, Panama,

California, Kerguelen, Philippines, W. coast of Africa, Canaries, Cape de Verd Is., Azores, Mediterranean.

Genus ECHINOCIDARIS, gen. nov. (*non Desmoulins*). *Duncan & Sladen*, 1885, *Journ. Linn. Soc.* vol. xix. p. 53. *Lovén*, 1887, *Ech. descr. by Linnæus*, pp. 81 & 95.

Syn. *Arbacia* (pars). (*Echinus niger*, Molina.)

Test regularly arched, circular in ambital outline, much wider than high, gibbous in the interradia at the ambitus. Some radial plates enter the oblique, elongate periproctal ring, and are usually small or as little knobs; periproctal plates normally four.

Ambulacra narrow abactinally, and very wide at the peristome; two rows of plain primary tubercles, separated by miliaries; plates, when compound, consisting about the ambitus, of four or five components, a large primary plate being adoral, the others all demi-plates, with more or less vertical inner sutures, are aboral. Pairs of pores polyserial at the peristome.

Interradia with high coronal plates above the ambitus, each with a large tubercle near the poriferous zone, and four smaller which extend towards the median suture, and are near the adoral sutures; minute secondary tubercles placed above the primaries. Near the peristome the plates are low, and there are many vertical rows of primaries, packed closely and without very definite order.

Peristome large, interradial ends very small, branchial cuts broad. One large pit for a single spheridium in each ambulacral median line near the peristome. Spines short on the dorsal part of the test except along the poriferous zones, where they are long. Tentacles heteropodous. Epistroma moderate.

The union of the vertical median sutures, and also between the ambulacra and interradia, is by dowelling and dovetailing; some plates have lamellæ or triangular prominences on their edges and the opposed plate-edges are correspondingly holed.

Recent. Patagonia and Peru.

Genus CŒLOPLEURUS, *Agassiz*, 1840, *Cat. Syst. Ectyp. Ech.* p. 19. *Desor*, 1858, *Synopsis*, p. 96. *A. Agassiz*, 1874, *Revision*, p. 267. *Duncan & Sladen*, 1883, *Pal. Ind.* ser. xiv., *Foss. Ech. Kachh and Kattywar*, p. 53; 1884–85, *Sind, Nari series*, pp. 251 et seq.; 1885, *Journ. Linn. Soc.* vol. xix. p. 27.

Test moderate in size, tumid and more or less circular in out-

line at the ambitus; subconical or depressed dorsally, flattish actinally.

Apical system large, with an elongate periproct with four or more large triangular plates; basals large, united; radial plates with a double perforation on the adoral edge.

Ambulacra narrow, with two vertical rows of primaries on flat scrobicules with well-developed bosses and mamelons, imperforate and non-crenulate, diminishing in size towards the apex and sometimes replaced there by granules. Poriferous zones narrow; pairs of pores in arcs near the ambitus and abactinally, some on the flanks of the tubercles, becoming slightly crowded actinally. Plates, primaries near the apex and becoming triple compound plates near the ambitus, consisting of a middle large primary plate and adoral and aboral short demi-plates; the sutures of the demi-plates and the middle primary bent on the flanks of the tubercle and then directed vertically adorally and aborally. Tentacles heteropodous.

Interradia with a large bare ornamented median area abactinally, and having the primary tubercles largest at the ambitus and diminishing in size towards the apical system or disappearing, placed on flat scrobicules, imperforate, and without crenulation, surrounded with granules.

Peristome with small branchial incisions and long tags; buccal membrane rugose near the teeth, with 10 small buccal plates, covered with pedicellariæ and with large disked tentacles, otherwise the membrane is bare. Perignathic girdle slender, ridges broad and low; the ambulacral processes moderate and usually arched. Teeth keeled. Dowelling occurs between the apical plates and between the interradial plates. Pits with spheridia at the median sutural junctions of the ambulacral plates near the peristome. Pedicellariæ with glandular stems.

The epistromal ornamentation very generally developed; the furrows and ridges and long lines of granules elongate or not, and in zigzag, by the side of and across the interradial bare spaces, and S-shaped bands occur in some species; the apical system also ornamented. Spines long, curved, more or less triangular in outline, cellular within, those of some primary tubercles very long, some spathulate.

Fossil. Eocene: England, Europe, N. America. Oligocene and Miocene: Europe, Asia.

Recent. Florida, the Caribbean Sea, Bourbon, Philippines, Amboyna, Indian Archipelago.

Genus PODOCIDARIS, *A. Agassiz*, 1869, *Bull. Mus. Comp. Zoöl.*; 1872, *Revision*, p. 269; 1881, *Report on 'Challenger' Ech.* p. 59; 1883, *Report on 'Blake' Ech.* p. 22.

Test moderate in size, pentangular or circular in tumid marginal outline, regularly arched but depressed abactinally, faintly tumid actinally around the large depressed peristome.

Apical system with large basal and radial plates; periproct small, with four or five triangular plates; anus at their inner points.

Ambulacra rising above the general level, broadest at the ambitus, and about equalling the interradia at the peristome. Primary tubercles plain, seen at the ambitus and actinally only, the rest of the interporiferous area being furnished with short sessile spines, with or without pits at their bases. Pairs of pores in simple series.

Interradia broad at the ambitus, and having the primary tubercles at the ambitus and actinally, the rest of the surface with sessile spines similar to those of the ambulacra.

Peristome large, pentagonal, depressed, with branchial incisions. Tentacles prehensile from the peristome to above the ambitus, and pointed and branchial abactinally. Peristomial membrane with buccal plates. Articulated spines restricted to the ambitus and under surface of the test, short and fusiform, or long and slender, striated, serrate, others without a socket and continuous with the test.

Recent. Caribbean Sea, 150 to 590 fathoms, and Philippines, 1050 to 1075 fathoms.

VII. Family TEMNOPLEURIDÆ.

Regular, ectobranchiate gnathostomes, with the teeth keeled, the pyramids of the jaws having epiphyses closing the foramen, the external branchiæ tufted or dactylose; the ambulacra with triple compound plates and subhomoiopodous tentacles; the suture of the ambulacral and interradial plates and of the apical system grooved and may be pitted, or there may be a raised ornamentation, costulate or reticulate or in ridges, the sutures being furrowed or not. Plates united by dowelling.

Subfamily *Glyphocyphinæ.*

Tumid tests with a large apical system, the basals low, and

either some or all the radial plates entering the periproctal ring, or the system is compact. Ornamentation raised, costulate or reticulate, with or without sutural furrows; sutural pits absent.

Subfamily *Temnopleurinæ* (p. 106).

Tumid or spheroidal tests with a compact apical system, the sutures grooved and pitted, "undermined" or not, the plates highly ornamented and united by dowelling.

Subfamily *Glyphocyphinæ*.

This subfamily may be divided artificially, into genera with large apical systems into the ring of which some radial plates enter, and into genera with solid apical systems.

Genus *Glyphocyphus.*
Dictyopleurus.
Arachniopleurus.
Ortholophus.
Paradoxechinus.
Echinocyphus.
Zeuglopleurus.
Lepidopleurus.
Leiocyphus.
Coptophyma.
Trigonocidaris.

Genus Glyphocyphus, *J. Haime*, 1853, *Anim. foss. de l'Inde*, p. 208. *Desor*, 1858, *Synopsis*, p. 102. *Cotteau*, 1859, *Éch. du Dépt. de la Sarthe*, p. 158, pl. xxviii.; 1862–67, *Pal. Franç., Terr. Crét.* vol. vii. p. 531; *Bull. Soc. Zool. de France*, 1886, p. 86. *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 36.

Test small, more or less tumid at the ambitus, broader than high, depressed spheroidal. Coronal plates moderately numerous. Epistroma highly developed.

Apical system large, all the basals and radial plates entering a narrow periproctal ring; madreporite small, punctures distinct; pore of the radial plates adoral; periproct large, elongate, ovoid.

Ambulacra narrow, straight, with two vertical rows of small,

perforate, crenulate, primary tubercles, largest actinally; boss spreading, mamelon globose and prominent, placed upon the aboral third of a plate; miliaries abundant, those nearest the tubercle elongate, and radiating more or less towards other miliaries which encircle them, arrangement confused further away. Plates high, compound, usually three pairs of pores and rarely four to a compound plate, almost in straight series or slightly in arcs; component plates are low, broad primaries with straight transverse sutures. On the tumid actinal surface a few large tubercles exist and sometimes alternate; they have distinctly radiating, long miliaries, resembling short costæ, between the boss and the usual circle of miliaries.

Interradia broad, with two vertical rows of primary tubercles, resembling, but slightly larger than, the ambulacral; a few secondary tubercles may exist; miliary tubercles numerous, irregularly placed near the edges of the plates, in circles around the bosses and united to them by more or less elongated ridges; a costa-like projection, or several, placed adorally to the primary tubercles, arising from them or from the adoral edge of a circle of surrounding miliaries, and thence extending to, or over, the adoral coronal suture of the plate. Tubercles and their surrounding radiations and circle of miliaries largest and most distinct actinally.

Ambulacral and interradial transverse sutures grooved, especially actinally to the tubercles, and the median sutures also.

Peristome small, sunken, with very slight branchial incisions.

Fossil. Cretaceous: England, Europe, and N. Africa. Middle Eocene: Europe. Upper Tertiary?: Europe.

A comparison of the drawings of *Glyphocyphus radiatus*, Höning. sp., in the works of Desor, Cotteau, and Wright will satisfy most students that either the variation of characters must be considerable or the details of structure have been drawn from indifferent specimens. Having had the advantage of examining perfect specimens, some of which are in the National Collection, it appears that the amount of variation is not great. It amounts to a stouter condition of the invariably narrow apical ring around the large periproct, especially of the anterior plates, the presence of an extra pair of pores in some ambulacral plates, a larger development of the ambulacral tubercles actinally, and the presence or absence of one or more short costa-like projections, placed adorally to each interradial tubercle. The grooving of the transverse sutures of the interradial coronal plates is not

a simple deepening along the line of suture, for the furrow is broad. In every specimen there is more of the radiation of the miliaries from a tubercle than is given in any drawing hitherto published, and the miliaries are much more crowded and irregular in shape than has been figured.

The raised nature of the epistromal ornamentation is seen around the spaces which occur along the transverse and the vertical sutures in well-preserved British specimens: it gives a very Temnopleurine appearance to the test. The figure given by Cotteau, Pal. Franç. vol. vii. pl. 1128, figs. 16–22, of *G. rugosus* shows the tubercles with four or five costæ projecting adorally instead of one, and recalls *Opechinus*, Desor. The sutures in this species are partly, but well grooved near the angles of plates.

Genus Dictyopleurus, *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 38.

Test small, hemispherical above, slightly concave actinally, more or less turban-shaped. Epistroma well developed.

Apical system: periproct oblique, elongate, elliptical, with a raised edge; basals unequal, with depressions between the foramina and the ring; radial plates large, some enter the narrow ring.

Ambulacra narrow, straight, pairs of pores in straight series; tubercles of the interporiferous area very small, in two vertical rows close to the poriferous zones, indistinctly crenulate and perforate, united by a zigzag of raised broad or narrow ridges. Each tubercle is connected with two of the opposed row, and with the tubercles placed above and below, by a raised rib-like ornamentation.

Interradia broad, with two vertical rows of primaries resembling those of the ambulacra, but more distinctly perforate and crenulated, united with those of the opposed row by a broad or narrow oblique or longitudinal, raised, granulated or not, series of costæ, and with the tubercle immediately above and below by means of a narrow vertical costa; the tubercles are raised above the common level. The sutural lines between the plates of both areas are visible, and are plain and not sunken.

Peristome small, and the branchial incisions also.

Fossil. Eocene: Asia (W. Sind), Africa (Egypt).

Genus ARACHNIOPLEURUS, *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 42.

Test depressed, tumid at the circular ambitus, rising but slightly abactinally. Epistroma well developed. Apical system large, defective.

Ambulacra narrow; pairs of pores in slight arcs, penetrating ridges which are continuous with radiating costæ coming from the scrobicular circle of the raised, small, perforate, crenulate tubercles of the interporiferous area. Tubercles of both areas in two vertical rows, each on a raised scrobicule from which radiate costæ, and the ends of these are surrounded by a circle of raised rib-like structure, carrying large granules. The circle gives off radiating costæ externally, some of which reach the circles of the opposed row of tubercles and others pass to the poriferous areas. Vertically the circles are more or less in apposition. Plates and sutures visible between the raised ornamentation.

Peristome small, deeply seated; branchial incisions small.

Fossil. Eocene: Asia (Sind).

Genus ORTHOLOPHUS, *Duncan*, 1887, *Quart. Journ. Geol. Soc.* vol. xliii. p. 414.

Test small, low, more or less pentagonal in marginal outline, subconical above the tumid ambitus. Epistroma well developed.

Apical system wanting. Periproct small and circular.

Ambulacra half of the width of the interradia at the ambitus, straight, with slightly sunken poriferous zones; pairs in ill-defined triplets, nearly in straight series, appearing on the actinal flanks of the costulation. Compound plates made up of a middle demi-plate and an adoral and aboral primary. A vertical row of small imperforate, non-crenulated primary tubercles is close to the poriferous zone in the interporiferous area; and the space between the rows is occupied by crowded, transverse, ridge-like costæ, passing from the opposite tubercles and carrying small secondaries.

Interradia with two vertical rows of primary tubercles, of the same size and shape as those of the ambulacra; their scrobicules raised, united with those placed actinally and dorsally by vertical, straight costæ, and with those of the opposite row by numerous crowded, transverse, straight costæ with small secondaries upon them.

Peristome small, almost without cuts.

Fossil. Australian Tertiaries (Mordialloc).

Genus PARADOXECHINUS, *Laube*, 1869, *Sitzungsb. d. kais. Akad. d. Wiss. Wien*, Bd. lix. p. 186, fig. 2. (*Amended.*)

Syn. *Coptechinus*, Cotteau, 1883.

Test small, depressed, much broader than high, tumid at the ambitus and slightly pentagonal in marginal outline, flat actinally. Epistroma well developed.

Apical system wanting, but was large, wide, and circular.

Interradia moderately broad, with a vertical row of primary tubercles near the ambulacra; the successive tubercles are united by a narrow fillet or ridge on which are two rows of small secondaries or large granules, and there is a zigzag of fillets composed of double rows of similar secondaries or granules between the opposite vertical rows of primary tubercles; moreover a zigzag exists, of corresponding structure, between the interradial and the ambulacral tubercles.

The ambulacral primaries are in two rows placed vertically, and there is a zigzag of raised fillets between them as in the interradia. The width of the ambulacra is very slightly less than that of the interradia, and the primary tubercles of both areas are subequal, smooth and non-crenulated. The test is deep and flat between the fillets, and the pairs of pores, three to a plate, in the ambulacra are on the deep part of the test and more or less in grooves.

The peristome is pentagonal, and the branchial cuts are slight.

Fossil. Miocene of Murray Cliffs, S. Australia.

Laube described one species, *P. novus*, and the dimensions of the specimen are important. Height 6·5 millim., diameter 13 millim., diameter of the apical scar 7 millim., diameter of peristome 4 millim. It is evident that the apical system was large, and from Laube's figure it would appear that all the radials reached between the basals to the periproct.

Cotteau has defined a genus *Coptechinus*, 1883, "Éch. nouv. ou peu connus," Bull. de la Soc. Zool. de la France, vol. viii. p. 456, from the Miocene of France, and it is synonymous with *Paradoxechinus*, Laube.

Genus ECHINOCYPHUS, *Cotteau*, 1859, *Éch. du Dépt. de la Sarthe*, p. 226, pl. xxxix. bis. fig. 6; 1862–67, *Pal. Franç. Terr. Crét.*

vol. vii. p. 707. *Wright*, 1870, *Pal. Soc., Monogr. Brit. Cret. Ech.* vol. i. pt. iii. p. 116. *Gregory*, 1889, *Ann. & Mag. Nat. Hist.* ser. 6, vol. iii. p. 490. (*Amended.*)

Syn. *Glyphocyphus* (pars).

Test small, tumid in circular or subpolygonal marginal outline, depressed, subconical or tumid dorsally, tumid actinally. Epistroma well developed.

Apical disk small, with the antero-lateral basal plates narrow and united; postero-lateral basals moderate in size, united to the antero-lateral basals, and meeting anteriorly to the periproct. Posterior basal absent in the type, but its impression left between the postero-lateral radial plates, both of which enter the periproctal area, denotes that it was broad from side to side and low. The anterior and antero-lateral radial plates are excluded. Periproct oval in shape, somewhat posterior.

Ambulacra straight, narrow, with some high plates placed abactinally to very low ones; two vertical rows of imperforate, crenulate, primary tubercles; mamelon globose, boss expanded, small abactinally, largest below the ambitus, where sometimes one may occupy nearly all the breadth of an ambulacrum; surrounded by stout and irregularly placed miliaries, or by compressed ridges which radiate from the tubercles. Poriferous zones narrow, pairs in very slight arcs, usually in triplets, and then the plate is made up of three low primaries with straight transverse sutures; or with four or even five pairs, but then the fourth and fifth pairs are in low primary plates independent of the high compound one. There may be some grooving of the ambulacral sutures and a continuity of ridges between the elevations, on which pairs of pores are placed, and ridges coming from the circular rows of miliaries around the interradial tubercles.

Interradia with two vertical rows of primary tubercles slightly larger than, but otherwise resembling, those of the ambulacra; miliaries radiating from the primaries compressed from side to side, or tear-shaped. The larger tubercles are actinal, and usually they have a circle of granules around the radiating series of compressed miliaries. Transverse coronal sutures simply and narrowly grooved.

Peristome small, sunken, with very small branchial incisions.

Fossil. Cretaceous: England, Europe.

Genus Zeuglopleurus, *Gregory*, 1889, *Ann. & Mag. Nat. Hist.* ser. 6, vol. iii. p. 494.

Syn. *Echinopsis* (pars); *Echinocyphus* (pars); *Glycocyphus* (pars).

Test small, globular, depressed below, slightly conical above; sides tumid. Epistroma well developed.

Apical disk somewhat solid, the two postero-lateral radial plates enter the periproctal ring; the antero-lateral pair of basal plates meet the adjoining basals, and thus the antero-lateral and anterior radial plates are excluded from the ring, while the periproct is pushed towards the posterior end; the posterior basal is very narrow. All plates perforated by the madreporite.

Ambulacra somewhat narrow and straight. Each bears two rows of primary tubercles, which are slightly smaller than those of the interradia, and are crenulate, imperforate, and surrounded by small scrobicules, broken by series of radiating costulate ridges which unite with those of the adjoining plates above and below; the rest of the plate with miliary granules arranged with some regularity. The horizontal sutures are notched with grooves much as in *Glyphocyphus*, which affect especially the adoral edge of the plate, so that the lower plate projects above the upper one. In the poriferous zones the pairs of pores are in single and nearly straight vertical rows; the plates nearest the apex are primaries; but proceeding actinally they become fused to compound plates of two or three primaries; a single primary is often intercalated between two compound plates.

Interradia one and a half times as wide as the ambulacra; the epistroma similar to that upon the ambulacral plates, but more developed. A single vertical row of primary tubercles on each side of each interradium; the tubercles larger than those of the ambulacra and connected by costulate ridges, and the rest of the plate is covered with very close miliary granules; a small row of secondary tubercles may be developed in the aboral external corner of each plate. Tubercles imperforate and crenulate.

Peristome about equal to the apical disk in size; branchial slits small.

Fossil. Cretaceous: England, Europe.

The type is *Zeuglopleurus costulatus*, Greg.

Genus LEPIDOPLEURUS, *Duncan & Sladen*, 1885, *Monogr. Foss. Ech. W. Sind, Pal. Ind.* ser. xiv. p. 306.

Test small, nearly hemispherical or turban-shaped.

Apical system large, solid; basal plates large; radial plates excluded from the ring, their pores adoral. Epistroma moderate.

Ambulacra small; poriferous zones slightly sunken, pairs of pores in simple series of triplets; plates composed of an aboral and larger adoral primary with an intermediate demi-plate; near the apical system are a few low primary plates. Interporiferous area crossed by a zigzag of raised granular ridges, uniting the tubercles.

Interradial plates scale-like, with the adoral edge overlapping a corresponding depression on the aboral edge of the actinally placed plate; two vertical rows of primary, plain tubercles connected by narrow, vertical ridges.

Peristome small, and the branchial incisions small. Transverse sutural lines sunken.

Fossil. Miocene: Asia.

Genus LEIOCYPHUS, *Cotteau*, 1866, *Pal. Franç., Terr. Crét.* vol. vii. p. 760, 1862–67.

Test small, circular at the ambitus, tumid dorsally, almost flat actinally.

Apical system narrow, not solid (judging from the shape of the space).

Ambulacra with narrow poriferous zones, with simple series of pairs of pores throughout; plates compound, and in triplets of primaries. Tubercles of both areas nearly equal, plain, subscrobiculate, somewhat elongated at the ambitus and dorsally, but losing this character actinally. Secondary tubercles compressed and elongate in the vertical direction abactinally, globular actinally. Coronal interradial plates moderate in number (14), with more or less deep grooves in the horizontal sutures.

Peristome small; branchial incisions very small.

Fossil. Cretaceous: Europe.

Genus COPTOPHYMA, *Péron et Gauthier*, 1879, *Éch. foss. de l'Algérie*, fasc. 5, p. 209, pl. xv.

Test small, tumid at the circular ambitus, subdepressed dorsally and flat or slightly tumid actinally.

Apical system well developed, with five large basals completing the large pentagonal periproctal ring; radial plates large.

Ambulacra narrow, with granules only in the interporiferous areas, some having mamelons. Pairs of pores in low, broad primary plates and in simple series abactinally and at the ambitus; actinally the series also persists, but there is a small demi-plate intercalated close to the median ambulacral suture actinally to large granules. This plate is sunken and has a pair of pores, but probably is not in connexion with the ambulacro-interradial suture.

Interradia with two rows of vertically placed, large, crenulated, imperforate tubercles, and no secondary tubercles. The transverse sutures below the tubercles are deeply grooved, the base of the tubercles being affected.

Peristome subcircular, with branchial incisions; the ambulacral lips as large as those of the interradia.

Fossil. Cretaceous: N. Africa.

Genus TRIGONOCIDARIS, *A. Agassiz*, 1869, *Bull. Mus. Comp. Zoöl.* vol. i.; 1872–74, *Revision*, p. 289; 1881, '*Challenger*' *Report*, p. 111.

Test small, thin, regularly arched above, circular in marginal outline, depressed actinally. Epistroma moderate.

Apical system ornamented or not, with very large basal plates, excluding the radial plates from the elongate periproct, which is covered by four plates, one being much the largest.

Ambulacra with two principal vertical rows of plain primary tubercles, united together by a reticulation of raised ornamentation, producing the appearance of ridges and furrows; pairs of pores in straight series.

Interradia with rows of plain tubercles slightly larger than those of the ambulacra, and joined by the same kind of ornament; sutures of the plates either in the furrows between the ridges or not visible; small secondary tubercles may be amongst the variable ornamentation.

Peristome with slight branchial incisions, the actinal membrane with ten buccal plates and others which imbricate. Spines moderately long, slender, striated.

Recent. Florida, Caribbean Sea; Josephine Bank; Kermadec Islands.

The genus requires more careful working out, and from the present knowledge of the species it should be classified with the *Glyphocyphinæ*, but it has alliances with the *Temnopleurinæ*.

Subfamily *Temnopleurinæ* (p. 97).

Genus *Temnopleurus.*
Subgenus *Pleurechinus.*
Genus *Temnechinus.*
Salmacis.
Subgenus *Salmacopsis.*
Genus *Mespilia.*
Microcyphus.
Amblypneustes.
Goniopneustes.
Holopneustes.

Genus incertæ sedis: *Grammechinus.*

Genus TEMNOPLEURUS, Agassiz, 1841, *Monogr. Éch. viv. et foss.*, *Preface to Valentin, Anat. Gen. Echinus*, p. 7. Herklots, 1854, *Foss. de Java* (*Leide*), p. 4, pl. i. Desor, 1858, *Synopsis*, p. 104. *A. Agassiz*, 1874, *Revision*, p. 460. *Martin*, 1880, *Rev. Foss. Ech. Java, Notes Leyd. Mus.* vol. ii. pp. 73–85. *J. Bell*, 1880, *Proc. Zool. Soc.* p. 422. *Duncan & Sladen*, 1883, *Pal. Ind.* ser. xiv., *Ech. Kachh & Kat.* p. 54. *Duncan*, 1883, *Journ. Linn. Soc.* vol. xvi. p. 350; 1888, *Ann. & Mag. Nat. Hist.* ser. 6, vol. i. p. 109.

Test stout, small and moderate in size, circular or slightly pentagonal at the tumid ambital outline, subconical and depressed abactinally, tumid and reentering around the small peristome. Coronal plates moderately numerous, with much epistroma.

Apical system small, compact, slightly projecting; basal plates thick, mostly united, the largest the right anterior containing the madreporite, which has circular pores; all have secondary tubercles for spines and a rather large genital perforation. Radial plates small, excluded, or one may enter, tumid, broad at their actinal edge and ornamented above with miliaries and small tubercles for pedicellariæ and spines. Pore situated adorally and divided externally by a vertical septum; furrows over the sutures and a deep pit actinally to each radial plate. Periproct variable in size and in the number and size of its plates*.

Ambulacra straight, narrow; pairs of pores in slight arcs of threes, the inner pore of a triplet the adoral; plates rather high, compound, made up of a large adoral primary containing the adoral

* See the variations shown on pl. viii., A. Agassiz, Revision, in *T. Hardwickii* and *T. Reynaudi* and compare with *T. toreumaticus.*

pair of pores, of a small demi-plate with the middle pair of pores, and an aboral low, wide primary with the aboral pair of pores of the triplet. Two vertical rows of well-developed primary tubercles in the interporiferous area, and large secondaries; some of the smaller secondaries and miliaries placed around the narrow depressed scrobicule of the primary tubercles, which have a large, conical, distinctly crenulate boss, and the well-developed mamelon is smooth and rounded. Tentacles stout and homoiopodous.

Interradia broad, with two vertical rows of primary tubercles resembling or slightly larger than those of the ambulacra, with numerous secondary tubercles arranged more or less around them, and miliaries; a process actinal to each tubercle.

All the plates of the test, except the component ambulacral plates, united by a dowelling of knobs and sockets. The transverse sutures of all plates grooved deeply and widely, either throughout their length or near the ends; deep pits at the angles of sutures and along the ambulacro-interradial sutures, undermining much of the test; pits large, in the ambulacral median line actinally and with large broad-topped spheridia.

Peristome small, branchial incisions very small, branchiæ narrow, dactylose: actinal membrane bare, only with ten small broad tentacular plates; perignathic girdle well developed, its foramen small, processes united. Pyramids of jaws with a tall foramen closed above by epiphyses; teeth keeled. Spines variable, moderate, slender, more or less compressed, striated, with a milled ring, sharp or blunt at the end, especially actinally. Many globiform pedicellariæ with short stalks and others with long stalks and long soft processes; similarly stalked small triphyllæ in great numbers.

Fossil. Tertiary: Java. Mekran Series: Persian Gulf. Subfossil: Red Sea.

Recent. Japan, Kamtschatka, Philippines, Arafura Sea, Mergui, Ceylon, China, E. Indian Islands, Persian Gulf, New Zealand.

Subgenus Pleurechinus, *Agassiz* (genus), 1841, *Monogr. d'Éch. viv. et foss.*, *Pref. to Valentin*, *Anat. Gen. Ech.* p. 8. *A. Agassiz*, 1873, *Revision*, p. 464; 1881, '*Challenger*' *Report*, p. 10. *Martin*, 1880, *Rev. Foss. Ech. Java*, *Notes Leyd. Mus.* vol. ii. pp. 73–85. *Duncan*, 1883, *Journ. Linn. Soc.* vol. xvi. p. 447.

Test rather high, apical system highly ornamented, grooves of

the sutures often or not with regular deep portions, and the pits deep at the angles, or sutures deep and plain. Tubercles plain or indistinctly crenulated. Knobs and sockets of the dowelling few in comparison with *Temnopleurus*.

Fossil. Tertiary: Java.

Recent. Japan; Arafura Sea.

The genus *Opechinus*, Desor, 1858, Synopsis, p. 107, has several shallow pits in each transverse coronal suture, and its author considers that there are recent and fossil species; amongst the first he instances none, but probably meant to refer to *Pleurechinus*; in enumerating and describing the fossil forms he mentions the so-called *Temnopleuri* of the Nummulitic of Sind. It has been shown (Duncan & Sladen, Pal. Ind. ser. xiv., Foss. Ech. of Sind, 1882, pt. ii. p. 36, and same series Ech. Kachh & Kattywar, 1883, p. 54) that the forms described by d'Archiac and Haime were not from the Nummulitic, but from the higher Tertiaries, and that they could not be separated from *Temnechinus*, Forbes. But it is quite evident that several of the *Temnechini*, when rolled and weathered, show several shallow pits along the transverse sutures. All the specimens seen by d'Archiac and Haime were in a most wretched condition, and are still in the museum of the Geological Society of London.

We do not consider that *Opechinus* is a good genus.

Genus TEMNECHINUS, *Forbes*, 1852, *Pal. Soc., Monogr. Brit. Tert. Ech.* p. 5. *Desor*, 1858, *Synopsis*, p. 105. *A. Agassiz*, 1872–74, *Revision*, p. 285; 1883, '*Blake*' *Echin.* p. 37. *Duncan & Sladen*, 1883, *Pal. Ind.* ser. xiv., *Ech. of Kachh &c.* p. 57.

Syn. *Opechinus*, Desor.

Small or moderate-sized tests, subglobular, depressed abactinally. Epistroma moderate.

Apical system prominent, sutures between the plates more or less grooved; a large periproctal plate and a few small anal ones *.

Ambulacra with a slightly undulating series of pairs of pores; pairs in triplets, the middle pair in a demi-plate, the adoral component a large primary, the aboral component a smaller primary; two vertical rows of small plain primaries in the interporiferous area. Interradia with primaries resembling those of the ambulacra but larger; some secondaries. Transverse sutures of

* This refers to *T. maculatus*, A. Ag., the recent species.

coronal plates variously and more or less deeply furrowed; grooves at the angles.

Peristome moderate, with branchial incisions; processes of perignathic girdle slender and closed above. Teeth keeled. Spines short and slender. (Occasionally a true pit, but not undermining the test, is seen at a sutural angle, and a crenulate tubercle is very rarely visible.)

Fossil. Miocene: W. Sind, Kach, Kattywar. Pliocene: England. Mekran Series: Persian Gulf.

Recent. Caribbean Sea, Florida; Azores; Josephine Bank. 30 to 600 fathoms.

It has been shown, Duncan & Sladen, Pal. Ind. ser. xiv., Ech. Kachh &c. p. 54 *et seq.*, that MM. d'Archiac and Haime were misinformed regarding the Nummulitic distribution of the *Temnechini* of Sind, and that the forms they described in 'Les Animaux foss. de l'Inde' as *Temnopleuri* were *Temnechini*. The habitat was clearly on a Miocene horizon.

Genus SALMACIS, *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.*, *Preface to Valentin, Anat. du Gen. Ech.* p. 8. *Desor*, 1858, *Synopsis*, p. 108. *A. Agassiz*, 1872–74, *Revision*, p. 471. *J. Bell*, 1880, *Proc. Zool. Soc.* p. 422. *Duncan*, 1883, *Journ. Linn. Soc.* vol. xvi. p. 345; 1888, *Ann. & Mag. Nat. Hist.* ser. 6, vol. i. p. 109. *Ramsay*, 1885, *Cat. Ech. Austr. Mus.* p. 47.

Test varying in size and shape, moderate and large, circular or subpentagonal in tumid ambital region, broader than high, subconical, globose abactinally, flattish or tumid actinally. Coronal plates numerous, low and broad.

Apical system moderate or small, the basal plates uniform except that bearing the madreporite, which is the largest, tuberculate around the ring, excluding or not some of the radial plates; sutures distinct. Periproctal membrane with small plates, some polygonal and carrying small spinules and small globiform pedicellariæ.

Ambulacra straight; poriferous zones broad, with small secondary tubercles; pairs of pores biserial in close but decided arcs of triplets, the middle pair of pores being nearest the ambulacro-interradial suture and in a demi-plate. The plates compound, broad and low, adoral component a large primary, the middle a demi-plate, the aboral a small low primary. Primary tubercles crenulate and imperforate, those of the interporiferous

zones largest and most numerous actinally, two rows reach the apex; secondary tubercles and granules exist; scrobicules small, raised or not.

Interradia much broader than the ambulacra, with numerous vertical rows of primaries, resembling those of the ambulacra, diminishing in number and size abactinally and allowing a broad median space to exist; secondaries and miliaries exist.

Plates of both areas with their lines of suture narrowly grooved, with small but well-defined, oblique, deep pits at the angles of junction of all plates, and along the ambulacro-interradial vertical sutures. Sutural edges of plates well dowelled.

Peristome small, subdecagonal, branchial incisions small. Branchiæ moderately large, with a stout base and bunches of finger-shaped processes. Perignathic girdle with well-developed ridges and tall processes, expanding above, united, and with a variably sized foramen. Foramen of the pyramids with a closed arch; teeth keeled. Peristomial membrane rugose near the teeth, plain elsewhere; ten buccal plates with large tentacles and small stalked pedicellariæ.

Tentacles subhomoiopodous, for the abactinal are very wide and long, feeble in muscular structure, yet the sucker-ring exists and is small; actinal and ambital tentacles disciferous. Spines short, delicate, striated, some sharp, others flat-ended.

Fossil. Eocene: Europe. Pliocene, Mekran Series: Persian Gulf.

Recent. Red Sea, Indian Ocean, Persian Gulf, Mergui, Philippines, Japan, Siam, Australian seas, E. coast of Africa.

Subgenus SALMACOPSIS, *Döderlein*, 1885 (genus), *Archiv für Naturg. Wiegm. Berlin*, Heft i. p. 93.

Test much broader than high, circular in ambital outline. Coronal plates high; tubercles few, small and smooth. Abactinally the plates near the median line are smooth. Pits sharp and angular, in the median line. Pores simple. Spines as in *Salmacis*.

Recent. Sigambai, Japan, 100–150 fathoms.

This is evidently a subgenus of *Salmacis*.

Genus MESPILIA, *Desor*, 1846, *Agass. & Desor*, *Cat. Rais.*, *Ann. Sci. Nat.* p. 357; *Synopsis*, 1858, p. 110. *A. Agassiz*, 1872–74, *Revision*, p. 477. *J. Bell*, 1880, *Proc. Zool. Soc.* p. 434. *Duncan*, 1888, *Ann. & Mag. Nat. Hist.* ser. 6, vol. i. pl. xi. fig. 5, p. 113.

Test moderate in size, thin, more or less globular or oblately

spheroidal and depressed, broader than high. Coronal plates numerous.

Apical system with a large periproct; the membrane with numerous plates, which are tuberculate; ring narrow, genital foramina large; basal plates broad, pentagonal, the madreporite distinct and in the largest; radial plates broad, excluded. Coronal plates numerous, low and broad.

Ambulacra moderate in width; poriferous zones broad; tubercles very small, placed near the poriferous zones only, abactinally, and closely packed throughout actinally. Median area broad, bare of primary tubercles, with pedicellariæ and granules; poriferous zones broad, with the pairs of pores in very close triplets, appearing to be biserial; the inner vertical row of pairs of pores the most numerous, formed by the adoral and aboral pairs of a triplet being nearly in vertical series; the middle pairs of pores are in the outer vertical row, each pair in a demi-plate, which is placed close to the ambulacro-interradial suture. Plates compound, low, broad; the adoral a large primary, the middle a small demi-plate, and the aboral constituent a small low primary.

Interradia broad, with a broad, bare, median space, bounded on either side by a belt of several close vertical rows of small tubercles resembling those of the ambulacra; actinally the tubercles are close and cover the plates. Sutures of the median series finely grooved in both areas; pits small, at the median angles. Dowelling occurs.

Peristome moderate, decagonal; branchial incisions small but broad, and with a lip. Perignathic ridges low, processes high, connected, foramen large. Pyramids of the jaws with a small foramen arched over; teeth keeled.

Spines small, short, slender; pedicellariæ very numerous.

Recent. Japan, Philippines, Samoa, Celebes, New Guinea, Sandwich Islands.

Genus Microcyphus, *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.*, *Preface to Valentin, Anat. Gen. Ech.* p. 8. *A. Agassiz*, 1872–74, *Revision*, p. 466. *J. Bell*, 1880, *Proc. Zool. Soc.* p. 422. *Duncan*, 1888, *Ann. & Mag. Nat. Hist.* ser. 6, vol. i. p. 113, pl. xi.

Test moderate in size, thick, tumid, prolately spheroidal, or depressed, circular or somewhat pentangular in ambital outline, contracted actinally. Coronal plates few and very high in the interradia.

Apical system small; basal plates broad; madreporite well defined; all radial plates small, excluded, ornamented; periproct small; genital foramina deeply cut.

Ambulacra rather broad, sunken or not in the median line and along the poriferous zone; with numerous rows of small, equal, plain, low primary tubercles, and small secondary tubercles, all more or less absent along the median line and along the edges of the plates near their upper and lower transverse sutures, but crowded on the plates elsewhere. Sutures grooved, and with pits at the angles, especially in the median lines. Pairs of pores in triplets, made biserial by the adoral pair being near the tubercular part of the plates, the other pairs forming a vertical row near the interradial suture. Plates compound, the adoral component a large primary, the middle a demi-plate, and the aboral a low primary plate. Some tubercles in the poriferous zone.

Interradia with few and very high coronal plates, with tubercles resembling those of the ambulacra, crowding the surface in horizontal rows except near the median and the transverse sutures, which are more or less bare; the bare spaces and also the masses of tubercles being triangular in outline. Median line sunken or not. Sutures slight, yet broadly depressed; pits at the angles of sutures minute.

Peristome variable, decagonal or nearly circular; branchial incisions small; ten buccal plates. Perignathic ridges well developed; processes large, tall, united over a large foramen.

Spines short and slender, shortest and tapering abactinally.

Dowelling of the plates distinct, near the free surface, and in lines passing into the test. Blocking out of some ambulacral plates occurs during growth.

Recent. Japan, East-Indian Islands, Philippines, Navigators, Tasmania.

Genus AMBLYPNEUSTES, *Agassiz*, 1841, *Monogr. Éch. viv. et foss.*, *Valentin*, *Anat. Gen. Ech.*, *Preface*, p. 9. *Desor*, 1858, *Synopsis*, p. 110. *A. Agassiz*, 1874, *Revision*, p. 478. *J. Bell*, 1880, *Proc. Zool. Soc.* p. 435, pl. xli. figs. 4–6. *Duncan*, 1883, *Journ. Linn. Soc.* vol. xvi. p. 354; *and* 1888, *Ann. & Mag. Nat. Hist.* ser. 6, vol. i. pl. xi. fig. 13, p. 116.

Test thin, moderate in size; circular or slightly pentagonal in tumid ambital outline, globular or prolate spheroidal. Coronal plates numerous.

Apical system small, slightly projecting; basal plates united; the genital pores at the adoral angle large or small according to sex; radial plates excluded, the pore visible from above; madreporite defined, openings circular; periproct with a crowd of small plates each with a miliary. Coronal plates numerous, low, broad.

Ambulacra broad, with rows of very small plain, faintly crenulate tubercles placed so as to leave a more or less definite median space, where there are pedicellariæ but no primary tubercles. Poriferous zones wide, with or without miliaries and secondaries; pores in oblique triple pairs, close vertically, the innermost pair is the adoral of a triplet. Plates numerous, compound; consisting, when large, of a large adoral primary plate, a small middle demi-plate, and a larger aboral demi-plate, which sometimes, especially abactinally in the test, becomes a primary plate.

Interradia with low broad plates; tubercles resembling those of the ambulacra, varying in vertical number and obliquity; a greater or less bare median space.

Sutures of both areas visible, narrow; minute shallow pits at the median angles, and sometimes along the median sutures; ornamentation plain, or of vertical zigzags of broad lines or of curved lines crossing the median area. Dowelling abundant.

Peristome variable in size, usually small; branchial incisions small. Perignathic ridges low, processes slender, high; foramen triangular or broad. Spines slender, short, striated, distant.

Recent. Australian and New Zealand seas, Fiji. (Cape of Good Hope ?)

Amblypneustes griseus is a very erratic species; and it is evident that A. Agassiz is correct in relegating *A. pentagonus* to a separate genus.

Genus GONIOPNEUSTES, gen. nov.

Test thin, nearly globular, but pentagonal in circumferential outline, the ambulacra projecting beyond the concave interradia. Coronal plates high and few.

Apical system delicate, with the madreporite in a large basal plate; other basals pointed, narrow, pentagonal; some radial plates enter the ring.

Ambulacra with two vertical rows of plain primary tubercles, with raised scrobicules; median spaces more or less bare; poriferous zones narrow; pairs of pores in triplets.

Interradia with tubercles resembling those of the ambulacra. Peristome small. Spines of primary tubercles of great size.

Recent. Mauritius.

The above diagnosis is abstracted from the description of the solitary specimen of *Amblypneustes pentagonus*, A. Agassiz (Revision, p. 482).

Genus HOLOPNEUSTES, *Agassiz*, 1841, *Éch. viv. et foss.*, *Valentin, Anat. Gen. Ech.*, *Preface*, p. 9. *A. Agassiz*, 1872–74, *Revision*, p. 483. *Bell*, 1880, *Proc. Zool. Soc.* p. 439. *Duncan*, 1888, *Ann. & Mag. Nat. Hist.* ser. 6, vol. i. pl. xi. figs. 14–16, p. 117.

Test moderately stout or thin, globular or prolately spheroidal, or subconical above the tumid circular ambitus. Interradial coronal plates numerous; ambulacral plates very numerous.

Apical system projecting, stout; basal plates broad, subequal; radial plates excluded, the pore visible from above.

Ambulacra broader than the interradia; and the poriferous zone usually broader than the interporiferous area, slightly depressed, with secondary tubercles and granules; pairs of pores close vertically, irregularly distant horizontally, triserial or polyserial; an inner and an outer regular vertical series of pairs, and a confused middle series. The middle series of pairs of pores are in the aboral components of as many compound plates; the pairs of the outer vertical row are those of middle component plates, and the inner series of pairs are placed in adoral primary components which are often excluded from the ambulacro-interradial suture.

Tubercles of the interporiferous areas small, plain, variable in number, more or less median space exposed. Interradia with transverse rows of primaries and secondary plain tubercles; median area variable.

Sutures sunken, linear; pits at the angles small, but distinct, shallow; plates dowelled.

Peristome small, pentagonal, with small but distinct branchial incisions. Spines short, striated, may be swollen at the free end.

Recent. Australian seas.

The next genus links the Temnopleuridæ and the Echinidæ, but it is placed as *incertæ sedis.*

Genus GRAMMECHINUS, *Duncan & Sladen*, 1885, *Pal. Ind.* ser. xiv., *Monogr. Tert. Echin. Kachh & Kattywar*, p. 82, pl. xiii. figs. 7, 8.

Test moderately large, thin, rather depressed, swollen at the circular ambitus, conical above, flat and incurved actinally.

Apical system ?

Ambulacra with pairs of pores in triplets, from apex to peristome; plates low, narrow, composed as in the Echinidæ; tubercles small, the vertical series nearest the pores the largest, in one or three rows, plain. Interradial plates long and low, not twice the height of an ambulacral plate, carrying from one to eight primaries, in vertical rows, the middle row the largest, all slightly larger than those of the ambulacra, imperforate and non-crenulate; secondary tubercles in lines above and below the primaries and close to the horizontal sutures, forming ridges, with the line of the suture depressed between those of consecutive plates. Vertical narrow ridges extending dorsally and actinally from each of the large middle vertical series of tubercles to the transverse edges of their plates.

Peristome large, rather pentagonal; ambulacral margins only moderately wide and plain; branchial incisions distinct, with a raised border.

Fossil. Miocene: Asia (Kattywar).

IV.

The Family Echinometridæ and its Subfamilies and Genera.
The Family Echinidæ and its Genera.

VIII. Family ECHINOMETRIDÆ, *Gray*, 1855, *amended by A. Agassiz*, 1872, *Revision*, p. 423.

Regular ectobranchiate gnathostomes, with heteropodous or sub-heteropodous tentacles; test with the long axis not coinciding with the antero-posterior, and the compound ambulacral plates with three or more pairs of pores; or the test symmetrical and polyporous. Pyramids of jaws with epiphyses; teeth keeled.

Subfamily *Echinometrinæ* (p. 116).

Large tests, the long axis transverse to or forming small angles with the antero-posterior. Ambulacral plates with from three to nine components, each with a pair of pores.

Genus *Heterocentrotus.*
Colobocentrotus.
Echinometra.
Stomopneustes.
Parasalenia.

Subfamily *Polyporinæ* (p. 121).

Echinometridæ with symmetrical tests and having numerous pairs of pores.

Genus *Strongylocentrotus.*
Sphærechinus.
Echinostrephus.
Pseudoboletia.
Eurypneustes.
Æolopneustes.

Subfamily *Echinometrinæ.*

Genus HETEROCENTROTUS, *Brandt* (subgenus), 1834–35, *Prodr. Desc. Anim.* p. 265; *Rec. d. Actes de l'Acad. St. Pétersb.* (*Additions*), 1834–35. *A. Agassiz*, 1873, *Revision*, p. 427. *Lovén*, 1874, *Études*, p. 26. *J. Bell*, 1881, *Proc. Zool. Soc.* p. 420. *De Loriol*, 1883, *Éch. de l'Ile Maurice*, p. 35. *Lovén*, 1887, *Ech. descr. by Linnæus*, p. 150.

Syn. *Cidaris* (pars), Klein; *Echinus* (pars), Linnæus; *Acrocladia*, A. Agassiz, 1846.

Test large, thick, elliptical in marginal outline, subhemispherical above, convex actinally, and concave from side to side there; elongate transversely, the antero-posterior axis being shorter than the transverse, which passes through ambulacra II. and IV.

Apical system raised; periproct small, slightly elliptical; the right anterior basal plate with a large madreporite; all basals tuberculate; radial plates excluded, tumid, perforated near the adoral edge; periproctal plates stout, spined; anal plates small. The genital pores are sometimes in the interradia.

Ambulacra broad, straight, wide at the peristome; interporiferous area narrow at the peristome, broad at the ambitus, and diminishing greatly in breadth abactinally; large plain tubercles actinally and at the ambitus, replaced abactinally by irregularly placed rows of secondary tubercles. Poriferous zone wide actinally, nearly touching at the median line abactinally, more or less broken up by tubercles. Plates compound, high, with as many

as nine components each perforated by a pair of pores; the aboral plate a small primary, the adoral a large primary, all the others demi-plates; pairs of pores polyserial actinally.

Interradia with few coronal plates, very narrow actinally, each plate with a large plain tubercle resembling the ambulacral, diminishing in size from the ambitus; secondary tubercles abundant.

Peristome large; branchial incisions broad; perignathic girdle well developed. Jaws with a tall narrow foramen; teeth keeled. Buccal plates large, spined, and with pedicellariæ. Spines very large, stout, long, flat, oar-shaped, or triangular in transverse section; secondary spines short, either forming a pavement around the primaries with their inflated ends, or sharp and pointed in the same position.

Recent. Red Sea to Sandwich Islands, Fiji, Mauritius, Java, New Caledonia, Australia. Of late years one species, *H. mamillatus*, has made its way from the Red Sea, *viâ* the Suez Canal, into the Mediterranean.

Genus Colobocentrotus, *Brandt* (subgenus), 1834, *Prodr. Desc. Anim.* p. 266; *Rec. d. l'Actes de l'Acad. St. Pétersb.* (*Additions*), 1834–35. *A. Agassiz*, 1872–74, *Revision*, p. 423. *Lovén*, *Études*, 1874, p. 26; 1887, *Ech. descr. by Linnæus*, p. 158. *J. Bell*, 1881, *Proc. Zool. Soc.* p. 421.

Syn. *Echinus* (pars), Linnæus; *Cidaris* (pars), Leske; *Echinometra*, Gray, 1825; *Podophora*, Agass.

Test thick, moderate in size, elliptical or subcircular in rather tumid marginal outline, subconical, tumid, or depressed hemispherical abactinally; more or less concave, with a comparatively flat surface actinally; elongate transversely; the antero-posterior axis is shorter than the transverse, which passes through amb. II. and IV.

Apical system central; periproct small, with small plates; basal plates large, with primary and secondary tubercles upon them; radial plates excluded, small, with a tubercle, and the pore large and adoral.

Ambulacra straight, very broad actinally; plates high, composed of a small aboral primary, a large adoral primary, and from three to many intermediate small demi-plates; poriferous zones wide, and containing arcs of many pairs of pores separated and

confused by the presence of tubercles; polyserial at the actinal surface, and forming broad areas there. Primary tubercles as elsewhere, plain, in vertical rows, smallest in the poriferous zone and largest at the margin, becoming minute and close actinally. Tentacles heteropodous.

Interradia broad, but very narrow actinally, with several vertical rows of primary tubercles, largest at the margin, and very small and close actinally.

Peristome polygonal, broad anteriorly, with decided branchial incisions. Perignathic girdle well developed; ridges long and low; processes tall, slender, with a top piece, foramen large. Jaws large, with a very long foramen; teeth keeled. Peristomial membrane plain, but with ten small, spined buccal plates. Spines abactinally forming a pavement-like surface, short, hexagonal or globose at the end, some larger, longer, flat-ended, and projecting slightly at the ambitus; actinally short, and either stout or slender, cylindrical and pointed. Intermediate cylindrical and small spines may or may not exist between the abactinal series.

Recent. Zanzibar, Java, Sandwich Islands, Australia.

Genus ECHINOMETRA, Rondelet, 1554, *De Pisc. Marin.* p. 578. *Lütken*, 1863, *Vidensk. Med. f. Nat. For. i Kjöbenh.*, pub. 1864, p. 86. *A. Agassiz*, 1872–74, *Revision*, pp. 282, 431. *Lovén*, 1872, *Études*, p. 26; 1887, *Ech. descr. by Linnæus*, p. 153.

Syn. *Echinus* (pars), Linnæus, 1758; *Cidaris* (pars), Leske, 1778; *Heliocidaris* (pars), Agass., 1847.

Test moderate in size, stout, elongate elliptical in marginal outline, tumid dorsally; tumid between the margin and the large peristome, the whole actinal surface concave; unsymmetrical; the longer axis, which passes through amb. I. and interradium 3, does not coincide with the antero-posterior or transverse diameter of the test and is oblique.

Apical system central; basal plates tuberculate, the madreporite in the right anterior plate; radial plates small; periproct elliptical, its plates small, numerous. Coronal plates numerous.

Ambulacra straight; poriferous zones moderately broad, the 5 to 9 pairs of pores being in bold arcs; plates high, and composed of a large adoral and small aboral primary and all the others intermediate demi-plates. Tentacles heteropodous.

Tubercles plain, and smaller and less numerous than those of the interradia.

Interradia broad at the ambitus, narrow at the peristome, with several vertical rows of large plain primary tubercles.

Peristome large, pentagonal; branchial incisions broad. Perignathic girdle well developed; processes tall, with a large arch. Jaw-pyramids stout, with a large tall foramen and epiphyses; teeth keeled. Actinal membrane with spine-bearing buccal plates. Spines of primary tubercles moderately long, stout, faintly longitudinally striated, semi-solid, becoming suddenly slender and sharp, with a milled ring.

Recent. Pacific coast of Central America north to California and south to Peru; Zanzibar, Red Sea, Mauritius, Seychelles, Japan, Philippines, Sandwich Islands, Fiji, Senegal coast, Cape Verd, Bermudas, Caribbean Sea, Gulf of Mexico.

Genus STOMOPNEUSTES, *Agassiz*, 1841, *Monogr. Éch. viv. et foss.* livr. 1, *Pref.* p. x. *A. Agassiz*, 1873, *Revision*, p. 436. *Martin*, 1880, *Rev. Foss. Ech. Java* (*Notes Leyd. Mus.*). *Stewart*, 1880, *Journ. Roy. Micr. Soc.* vol. iii. p. 911. *J. Bell*, 1881, *Proc. Zool. Soc.* p. 445. *De Loriol*, 1883, *Éch. de l'Ile Maurice*, p. 32.

Syn. *Heliocidaris*, Desm. 1846.

Test moderate in size to very large, stout, circular or elliptical in the tumid marginal outline, swollen dorsally, but depressed; actinal surface flat. The antero-posterior axis of the test is oblique and forms a greater or less angle with the long diameter.

Apical system with a large madreporite; basal plates forming a narrow ring, with a secondary tubercle on each plate. Periproct large, with numerous plates with small tubercles.

Ambulacra straight, broad at the ambitus and at the peristome; poriferous zones narrow abactinally and wide actinally; the pores in arcs of three pairs dorsally, and crowded and triserial below the ambitus, and interfered with nearly throughout by small secondary tubercles or granules. Interporiferous areas with two vertical rows of large, imperforate, plain, primary tubercles, and several rows of secondary tubercles and miliaries, some entering the poriferous zones, diminishing at the peristome, where the areas are narrow. Spicules of the tentacles very large.

Interradia with a linear groove in the median line, broad above the ambitus, narrow at the peristome, with two principal vertical rows of primary tubercles resembling those of the ambulacra in structure, but larger, diminishing, however, in size actinally and dorsally. There are also two rows of smaller primaries, smallest actinally, which reach some distance above the ambitus, with small secondary tubercles and granules irregularly distributed.

Peristome small, pentagonal, with moderately large branchial incisions.

Spines various, but moderate in length, stout, tapering, sharp, solid, finely striated longitudinally; a prominent milled ring. Ophiocephalous pedicellariæ abundant, large, their jaw-processes much dentate; gemmiform pedicellariæ probably absent; tridactyle pedicellariæ abundant.

Fossil. Tertiary: Java?

Recent. Mauritius, Java, Samoa.

Genus Parasalenia, *A. Agassiz*, 1863, *Bull. Mus. Comp. Zoöl.* vol. i. p. 22; 1873, *Revision*, p. 435. *Stewart*, 1880, *Journ. Royal Micr. Soc.* vol. iii. p. 910.

Test moderate in size, stout, elliptical, tumid, unsymmetrical, the long axis passes through ambulacrum I. and interradium 3, and is oblique to the antero-posterior axis.

Apical system large, prominent. Basal plates large. Periproct small, with four triangular plates; anus at their inner points.

Ambulacra with two vertical rows of plain primary tubercles, not reaching the apical system; pairs of pores in arcs of three pairs.

Interradia with a small number of coronal plates, carrying two vertical rows of plain primary tubercles resembling those of the ambulacra.

Peristome large; branchial incisions slightly raised; buccal plates with spinules. Jaws with a high foramen; teeth keeled. Spines stout, cylindrical, pointed, moderately long.

Pedicellariæ few, the gemmiform without a secondary solid fang. Tridactyle pedicellariæ delicate.

Recent. Zanzibar, Kingsmill Islands, Bonin Islands.

Subfamily *Polyporinæ* (p. 116).

Genus Strongylocentrotus, *Brandt*, 1834, *Prodr. Descr. Anim.*, *Rec. des Actes de l'Acad. St. Pétersb.* (*Additions*), p. 265. *Lovén*, *Études*, 1874, p. 21 (*as* Toxopneustes). *A. Agassiz*, 1872–73, *Revision*, pp. 276 & 438.

Syn. *Loxechinus*, Desor, 1858; *Toxopneustes*, Agass., 1841 (pars); *Heterocidaris*, Desm., 1846 (pars); *Toxocidaris*, A. Agass., 1863; *Anthocidaris*, Lütk., 1864; *Eurechinus*, Verr., 1866.

Test moderate and large in size, broader than high, circular or subpentagonal in tumid ambital outline, swollen, subconical, depressed dorsally, slightly tumid around the actinostome. Coronal plates numerous.

Apical system large; madreporite large, in the usual basal plate, which is the largest; other basal plates unequal in size, all with some small secondary tubercles; radial plates broad adorally, some entering the periproctal ring. Periproct subcircular, with numerous crowded, minutely tuberculate plates.

Ambulacra straight, broad at the ambitus and peristome; poriferous zones broad; pairs of pores in oblique arcs, or almost in transverse, slightly bent series of from four to eight or ten pairs, polyserial and crowded actinally. Plates high, compound; the adoral component a large primary plate with its pair of pores the remotest from the interradium; the aboral plate a small primary with an oblique adoral suture, its pair of pores not quite so remote from the interradium as the adoral pair; other plates demi-plates, with their pairs of pores gradually diminishing in distance from the interradium, from above actinally. Interporiferous area with two vertical rows of imperforate plain non-scrobiculate primary tubercles, wide apart at the ambitus, narrowed and close and small actinally; vertical rows of secondaries and miliaries between and at the sides, some intruding upon the poriferous zones and separating the arcs more or less.

Interradia with high ambital and low actinal plates; two vertical rows of primary tubercles similar in structure to, but larger than, those of the ambulacra, and four or more vertical rows of secondary tubercles; granules somewhat regularly placed; areas much narrower actinally than those of the ambulacra.

Peristome small, sunken, polygonal; branchial incisions well developed, with everted edges.

Perignathic girdle with high ridges and high oblique processes forming a tall arch. Jaws tall; foramen large, tall, closed above; teeth keeled. Buccal membrane with ten plates with tentacles and pedicellariæ. Spines short, sharp, cylindrical, tapering, longitudinally striated.

Fossil. Late Tertiary and (?) Miocene: Europe and America, Java.

Recent. European seas, world-wide; shallow, to 45 fathoms or more.

Genus SPHÆRECHINUS, *Desor*, 1858, *Synopsis*, p. 134. *A. Agassiz*, 1873, *Revision*, p. 451. *Hamann*, 1886, *Sonder-Abdr. aus d. Sitzungsb. d. Jenaisch. Ges. für Med. und Naturw.*

Test moderate or large, globular, spheroidal, or depressed, flat actinally. Coronal plates numerous, low and broad.

Apical system prominent; periproct large, plated; basal plates forming with all or some of the radial plates a rather narrow ring, carrying secondary tubercles and miliaries, those on the plate with the madreporite most numerous.

Ambulacra straight, wide; pairs of pores in arcs or oblique lines of from four to eight pairs, with small tubercles or granules interposing or separating the series; pairs polyserial actinally; interporiferous areas with two to six vertical rows of plain imperforate primary tubercles, slightly smaller than or equal to those of the interradia.

Interradia broad, with from two to twelve vertical rows of primaries plain and imperforate, large, with horizontal rows of secondary tubercles and miliaries.

Peristome small, decagonal, with deep, long branchial incisions; buccal membrane with plates, in relation with the ambulacra, and carrying pedicellariæ and large tentacles. Perignathic girdle slender, with low stout ridges and slender processes and a large arch. Spines stout, short, crowded. "Globifera" pedicellariæ present and large.

Fossil. Pliocene: Europe.

Recent. Mediterranean, Canaries, Australia, Mauritius, New Zealand, Japan, and the China seas.

Genus ECHINOSTREPHUS, *A. Agassiz*, 1863, *Bull. Mus. Comp. Zoöl.* vol. i. p. 20; 1873, *Revision*, p. 457. *Stewart*, 1880, *Journ. Roy. Micr. Soc.* vol. iii. p. 909. *De Loriol*, 1883, *Éch. de l'Ile Maurice*, p. 31.

Test moderate in size, circular or pentagonal in tumid ambital outline, turban-shaped, but depressed above and widest there, flat below. Plates rather numerous, high actinally, low and broad dorsally.

Apical system circular, large; the ring narrow; basal plates equal and large; the radial plates small and wedged in between the basals, but excluded; periproct polygonal, and with large and small plates.

Ambulacra with rather broad poriferous zones; pores in arcs of three or four pairs; interporiferous area with two rows of vertically placed, imperforate and plain, primary tubercles flanked by a vertical row of smaller tubercles placed near the poriferous zone; median area with secondary tubercles and miliaries, arranged more or less around the primary tubercles.

Interradia broad, with six to ten vertical rows of uniform, imperforate, plain primary tubercles resembling those of the ambulacra, diminishing in size and number away from the ambitus; miliaries and secondary tubercles scattered actinally, arranged around the primaries dorsally.

Peristome circular, with small branchial incisions; buccal membrane with plates in continuation with the ambulacra, carrying pedicellariæ and tentacles; the rest bare.

Perignathic girdle with low ridges and well-developed processes.

Spines moderate, tapering, cylindrical, stout, sharp, longest dorsally.

Recent. Pacific Ocean, Society Islands, Zanzibar, Natal.

Genus PSEUDOBOLETIA, *Troschel*, 1869, *Verhandl. d. Naturhist. Ver. preuss. Rheinl. u. Westfalens*, ser 3, vol. vi. p. 96, pl. 26. *A. Agassiz*, 1873, *Revision*, p. 454. *J. Bell*, 1881, *Proc. Zool. Soc.* p. 433. *De Loriol*, 1883, *Ech. de l'Ile Maurice*, p. 28.

Test moderate and large, circular in tumid ambital outline, much broader than high, subconical, depressed dorsally, and flat actinally. Coronal plates numerous, low and broad.

Apical system small, with the basal plates unequal in size, madreporite in the largest; two postero-lateral radial plates

separate basals and enter the ring. Periproct small; plates uniform in size except close to the anus, where they are small, tuberculated.

Ambulacra straight, broad, with four to six rows of primary tubercles, plain and imperforate, with circles of granules around them, scarcely smaller than those of the interradia, all but the external series disappearing towards the apex; poriferous zones broad, with small tubercles between the pairs. Pairs of pores in arcs of four pairs or triserial; the inner row consists of adoral pairs in the adoral primary plates of the compound plates; the outer vertical row consists of series of two pairs closely superimposed, and separated by a tubercle, they are in middle demi-plates; the middle vertical row has its pairs separated by a tubercle, and they are in the aboral demi-plates.

Interradia with many, from 9–14, vertical rows of primary tubercles, similar in structure to those of the ambulacra, diminishing to two vertical rows abactinally; an irregular median area without tubercles; scrobicular circles large; miliaries parallel to the horizontal sutures, and vertically between the tubercles; secondary tubercles scattered irregularly.

Peristome large, flush, decagonal, with broad and deep branchial incisions. The buccal membrane with ten large plates with spines, pedicellariæ, and tentacles, also other spiniferous small plates. Spines short, sharp, finely striated.

Recent. Sandwich Islands, Philippines, Mauritius; shallow water.

Genus EURYPNEUSTES, *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pt. ii. p. 45.

Test large, subconical, depressed.

Ambulacral areas very broad, only rather narrower than the interradia. Poriferous zones broad, and the pairs of pores triserial. Plates very low and numerous, composed of five or six component plates, very close vertically, the adoral plate a very low primary, its pair of pores being near the interporiferous area; the other plates demi-plates, or sometimes the aboral component is a primary; the successive pairs have a tendency to be close to the one immediately above, and then to be distant, but the inner and outer rows are fairly persistent, and the middle variable in position. Two vertical rows of small crenu-

late, imperforate tubercles in each interporiferous area near the poriferous zones; small tubercles or granules near them amongst the pairs of pores.

Interradia with two or more vertical rows of small crenulate tubercles diminishing in number actinally. Miliaries numerous.

Fossil. Eocene: W. Sind, Asia.

Genus ÆOLOPNEUSTES, *Duncan and Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pt. ii. p. 47.

Test large, tumid, subcircular or subpentagonal in outline, subconical depressed abactinally, flat actinally, with a slightly depressed peristome. Twice as broad as high.

Apical system wanting.

Ambulacra broad, more than half of the breadth of the interradia at the ambitus, slightly prominent in contradistinction to the interradia, which are sunken along their median lines. Poriferous zone broad dorsally, narrow at the peristome; abactinally the pores are in almost horizontal arcs of five or six pairs, and are very regularly and closely placed; below the ambitus the number of pairs in each arc diminishes, the arcs straighten vertically, and the series of pairs become less oblique and almost uniserial, and are quite close to the peristome. The ambulacral plates are nearly as high as the corresponding interradial plates and are compound; the composition of a plate halfway between the peristome and the ambitus is a low broad adoral primary plate, followed aborally by a large primary which is low near the ambulacro-interradial suture and expanded elsewhere, and comprises all the median sutural edge of the compound plate except that adoral portion which belongs to the small adoral primary component; above the large primary is a small demi-plate, and the aboral plate of the combination is also a demi-plate, but is larger than the other, and has its adoral suture convex towards the primary tubercle of the compound plate. In some compound plates the low adoral primary is replaced by a small low demi-plate, with its aboral suture convex towards the primary tubercle; and in these instances the composition of the plate is mainly that of *Diadema.* Close to the peristome the adoral and aboral plates are low primaries. The pairs of pores are close and round. Interporiferous areas with a vertical row of small crenulate primary tubercles raised above the test and large and small granules.

The interradia have numerous low broad plates, somewhat wavy in sutural outline, depressed near the median line; two vertical rows of primary tubercles resembling those of the ambulacra, but slightly larger, and two other rows of smaller tubercles which diminish in number remote from the ambitus; numerous distant large granules.

Peristome small, sunken; branchial incisions with rounded edges and rather large.

Fossil. Eocene: W. Sind, Asia.

IX. Family ECHINIDÆ.

Regular ectobranchiate gnathostomes, having tests with equal diameters, and with homoiopodous tentacles. Ambulacral plates compound, with three pairs of pores, which are arranged in high or low arcs of triplets. Coronal plates without pits and grooves, and their opposed surfaces plain. Jaws with epiphyses teeth keeled.

Genus *Echinus*.
Subgenus *Psammechinus*.
Genus *Stirechinus*.
Glyptechinus.
Leiopedina.
Hypechinus.
Toxopneustes.
Boletia.
Genus *Tripneustes*.
Subgenus *Evechinus*.

Incertæ sedis: *Prionechinus*.

Genus ECHINUS, Rondelet, *De Pisc. Marin.* 1554. Lister, 1678, *Anim. Ang.* p. 169, pl. 3. fig. 18. *Linnæus*, 1752–64, *Mus. Lud.-Ulr.* (pars). *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.*, *Pref. to Valentin, Anat. Gen. Echin.* p. 2. *Desor*, 1858, *Synopsis*, p. 123. *A. Agassiz*, 1872–4, *Revision*, pp. 293 & 489. *Lovén*, 1887, *Ech. descr. by Linn.* pp. 49 & 61.

Test varying in size, small, moderate, to very large, tumid at the circular or subpentagonal ambitus, subhemispherical, subconical, or tumid dorsally, flat or slightly tumid actinally, tall and short.

Apical system either compact, or some radial plates separating some basal plates; madreporite in the largest basal. The oval or circular periproct with numerous plates, smallest near the anus.

Ambulacra narrow to moderately wide, straight; poriferous zones narrow, pairs in more or less vertical arcs of triplets, the innermost pair the adoral of the three, and in a primary constituent; the other pairs in demi-plates, or the upper member may be a low primary. Interporiferous areas with two rows of small, plain, primary tubercles, placed vertically, with or without irregularly placed secondary tubercles and primaries.

Interradia with two vertical rows of tubercles resembling those of the ambulacra, or slightly larger, with few or numerous rows of secondary tubercles and miliaries, or a considerable number of small tubercles diminishing in number abactinally; tubercles most numerous below the ambitus.

Peristome rather small, nearly circular; branchial incisions not large; perignathic girdle well developed, processes tall and arched. Jaws high; foramen of the pyramid high and arched by epiphyses; teeth keeled. Buccal membrane with ten buccal plates with tentacles and small spines; some may have numerous buccal plates with a corrugated aspect. Tentacles homoiopodous, disciferous. Spines either very short relatively or moderately long, striated, sharp, more or less swollen at the base.

Fossil. Cretaceous to Pliocene and Post-Pliocene: Europe. Pliocene: England. Tertiary: Asia.

Recent. World-wide, littoral to 2435 fathoms.

The genus *Psammechinus*, Agass., 1846, Catal. Rais., Ann. d. Sci. Nat. vol. vi., and Desor, 1858, Synopsis, p. 118, really differs from the typical *Echini* in having the buccal membrane with concentric plates besides the ten buccal plates; but palæontologists have usually termed those species of *Echinus* which have numerous subequal tubercles *Psammechinus.* The size of the branchial incisions does not afford a generic distinction. Desor was not warranted in comparing the buccal and other plates with those of *Cidaris.* It is certain that some *Echini* with few tubercles, as well as others with many, have the peristomial membrane with numerous plates; and thus the distinction relied upon fails. At the most *Psammechinus* is a subgenus of *Echinus*; and the sole structural character refers to the peri-

stomial membrane with its numerous plates. Practically the subgenus is of no great value *.

Genus STIRECHINUS, *Desor*, 1858, *Synopsis*, p. 131.

Test tall, circular at the tumid ambitus, subconical dorsally, flat actinally.

Apical system ?

Ambulacra moderately broad, with high compound plates; the pairs of pores in arcs of triplets, the adoral plate of the compound a large primary, the median plate a demi-plate, and the aboral a low oblique primary plate. Two vertical rows of imperforate, plain, primary tubercles, large, and each situated upon a rising of the plate, so as to give a keeled appearance to the ambulacrum beneath the bases of the tubercles.

Interradia with two vertical rows of tubercles resembling those of the ambulacra, and situated on raised keel-like projections. Sutures distinct. Variable rows of secondary tubercles and miliaries.

Fossil. Pliocene: Europe.

Genus GLYPTECHINUS, *De Loriol*, 1873, *Éch. Crét. de la Suisse, Pal. Suisse, les Oursins*, pt. ii. p. 169, pl. xi.

Test small, circular in outline, tall, subconical or subhemispherical dorsally, flat actinally.

Apical system wanting.

Ambulacra straight, moderately broad; the poriferous zones with the pairs of pores in arcs or triple oblique series; the plates compound, as in *Echinus*; the interporiferous areas with two vertical rows of plain tubercles, placed near the poriferous zones; some secondaries at the ambitus, and granular throughout.

Interradia depressed along the median sutures, with two vertical rows of plain tubercles resembling those of the ambulacra; each row is on a raised vertical keel, situated in the middle of the plates; several rows of secondary tubercles. The transverse sutures of the interradial coronal plates, which are moderately numerous, grooved decidedly.

Fossil. Cretaceous: Europe.

The alliance of this genus is with the Tertiary *Stirechinus*.

* On p. 91 it was noticed that *Micropsis Vidali*, Cott., was a *Psammechinus* with crenulate and perforate primary tubercles. This carries the subgenus back in time considerably.

Genus LEIOPEDINA, *Cotteau*, 1866, *Rev. et Mag. de Zool.* sér. 2, vol. xviii. p. 206. (*Amended.*)

Syn. *Chrysomelon*, Laube, 1869, Ech. Vincent. Tert., Denks. d. k. Akad. Wiss. Wien, 2 Abth. p. 13.

Test large, swollen, prolate spheroidal or globular, subconical dorsally, broadest beneath the equator, and subpentagonal or circular in marginal outline.

Apical system central, small, flush.

Ambulacra long, straight, very broad; poriferous zones broad, with vertically close, triserial pairs of pores almost horizontal; usually the pair nearest the interporiferous area the largest, the pores of it being elongate, those of the other pairs circular. Plates very numerous, low, broad, compound, composed of a large adoral primary plate, a median demi-plate, and a very low aboral primary plate. The adoral and aboral pairs of pores of a triplet remote from the interradium; the median pair in the demi-plate, close to it. Tubercles of the interporiferous areas small, distant, finely perforate, plain, subscrobiculate, in two, distant, vertical rows. Granules between the tubercles homogeneous.

Interradia broad, with two vertical rows of tubercles similar to those of the ambulacra, with intermediate granules, some of which may have mamelons near the apical system.

Peristome small, subcircular, flush; amount of branchial incision variable.

Fossil. Eocene: Europe.

Genus HYPECHINUS, *Desor*, 1858, *Synopsis*, p. 130, pl. xviii.

Test moderate in size, tumid at the circular ambitus, nearly hemispherical dorsally, but slightly depressed.

Ambulacra with wide poriferous zones; pairs of pores in oblique triple series; plates low, compound; the median pair of pores being in a demi-plate, and placed nearer the interradial suture than the other pairs; the adoral pair very remote from the interradial suture and in a primary plate. Interporiferous areas with two vertical rows of small, numerous, plain primary tubercles, which are much larger actinally than above the ambitus.

Interradia with numerous coronal plates; the primary tubercles imperforate and plain, in two distant vertical rows; the tubercles

are larger than those of the ambulacra, and all are largest actinally.

Fossil. Middle or Upper Tertiary: Patagonia, S. America.

The genus *Toxopneustes*, Agassiz, 1841, is unsatisfactory; and in order to clear away some differences of opinion regarding its value, it is necessary to revert to the diagnosis given in the Preface to livr. 4 of 'Monogr. d'Éch. viv. et foss.' p. ix:—"Le genre *Toxopneustes* a des ambulacres formés de séries arquées de doubles pores, convergeant vers le milieu des aires et séparées par des rangées parallèles de petites *pores*. Chaque série arquée se compose de six à neuf paires de pores. Vers la bouche il y en a moins; mais elles sont plus rapprochées. Les tubercules des séries principales sont assez grands. L'ouverture inférieure du test offre dix échancrures peu profondes. Je prends pour type de ce genre l'*Echinus tuberculatus*; j'en connai quelques espèces inédites."

The genus had been simply named in livr. 2, p. 7, of the same work during the same year; and *Echinus pileolus*, Lmk., was then decided to be the type.

It is evident that Agassiz meant that the genus should include polypores; and the word "*pores*," at the close of the first sentence of the definition given above, should be "tubercules." The genus thus covered the same ground as *Strongylocentrotus*, Brandt, 1835.

The reason why *Echinus pileolus* was not made the type, when the genus was finally diagnosed by Agassiz is tolerably evident; for it is not a polypore, and is more closely allied to a *Tripneustes* than to *Echinus tuberculatus*.

On reference to A. Agassiz's 'Revision,' p. 167, the synonymy of the genus can be seen; and it will be noticed that no less than six genera have been founded which cover the same ground. *Toxopneustes* did not reappear until the date of the 'Revision,' and four species of it are admitted by the distinguished author—*T. maculatus*, *T. pileolus*, *T. semituberculatus*, *T. variegatus*. But it is a matter of fact that not one of these species has the generic characters defined by the elder Agassiz in the 'Monographie.'

There is therefore no such genus as *Toxopneustes*, Agassiz; he merely gave a name, and his diagnosis did not distinguish his two types. In the 'Revision' of A. Agassiz, p. 297, there is a generic definition of *Toxopneustes* which differs very materially

from that of his father, and which may stand for the generic attribute of three out of the four species admitted and just noticed. *T. pileolus* cannot well enter, as De Loriol has shown, (Éch. de l'Ile Maurice,' p. 27).

Genus Toxopneustes, *A. Agassiz*, 1872–4, *Revision*, p. 297. (*Limited.*)

Non *Agassiz*, 1841, *Préf. Monogr. d'Éch. viv. et foss.* livr. 4, p. ix. = Strongylocentrotus, *Brandt*, 1835.

Test moderate in size, circular or subpentagonal in tumid marginal outline, subconical, broader than high.

Apical system well developed, some radial plates entering the periproctal ring or not.

Ambulacra moderately broad; the pairs of pores forming broad arcs of three pairs, rather close vertically, and the pairs of the arc not far apart; the inner pairs of pores are adoral in the triple compound plates, which are like those of *Echinus*. Interporiferous areas with two principal vertical rows of plain imperforate primary tubercles moderate in size, with rows of secondaries with or without granules; most tubercles at and below the ambitus.

Interradia with several vertical rows of primary tubercles resembling those of the ambulacra, diminishing to two near the apex, granular or not. Bare median spaces variable or none.

Peristome large, usually but not invariably with deep incisions for the branchiæ. Jaws and teeth as in *Echinus*. Buccal plates and also concentric, wide, low plates in the membrane. Spines short, moderately stout.

Recent. From the coast of Brazil to Carolina inclusive, and the Caribbean Islands; Bermuda; Christmas Island; Bourbon; Galapagos; Central (Pacific) America.

Toxopneustes pileolus, A. Ag., = *Echinus pileolus.*, Lmk., is a *Boletia.*

Genus Boletia, *Desor*, 1858, *Synopsis*, p. 133; 1847, *Catal. Rais.*, *Ann. d. Sci. Nat.* vol. vi. p. 58. *Verrill*, 1871, *Notes on Radiata*, p. 581. *De Loriol*, 1882, *Éch. de l'Ile Maurice*, p. 27.

Syn. *Toxopneustes* (pars).

Test moderate and large, thick, subpentagonal at the tumid ambitus, subconical dorsally, concave actinally, broader than high; the ambulacra projecting somewhat.

Apical system large, madreporite large, and in the largest basal plate (No. 2); some radial plates enter the periproct.

Ambulacra broad, with numerous, low, compound plates; poriferous zones broad, the pairs numerous, close vertically, but moderately far apart in the slightly inclined arcs or straight and horizontal series of three pairs. The plates as in *Tripneustes*, but slightly higher and narrower. Small tubercles in the poriferous zones; interporiferous areas with several vertical rows of moderately large primary tubercles, diminishing in number above the ambitus.

Interradia with numerous rows of plain, primary tubercles resembling those of the ambulacra, diminishing in number apically. A more or less bare space on either side of the median ambulacral and interradial lines near the apical system.

Peristome large, with deep and long incisions for the branchiæ, the edges turned up. Pedicellariæ very large. Spines small, striated.

Recent. Mauritius, East Indian Islands, Pacific Islands, Panama.

The alliance to *Tripneustes* is close, the main distinctions being the shape and the concave actinal surface with its large well-cut peristome; the poriferous zones are also narrower in *Boletia* and a more arched arrangement of pairs occurs, remote from the ambitus, where the structure of the ambulacral plates is as in *Tripneustes*; there are no double plates, however, as in the fossil *Tripneustes*.

Genus TRIPNEUSTES, *Agassiz*, 1841, *Introd. to* livr. 2, *Monogr. d'Éch. viv. et foss.* p. 7; also 1841, *Monogr. d'Éch. viv. et foss.* livr. 4, *Preface to Val. Anat. d'Éch.* p. viii. *Desor*, 1858, *Synopsis*, p. 132. *Lütken*, 1863 (pub. 1864), *Vid. Medd. f. Nat. For. i. Kjöb.* p. 95. *A. Agassiz*, 1872–4, *Revision*, p. 301. *J. Bell*, 1879, *Proc. Zool. Soc.* p. 655. *De Loriol*, 1883, *Éch. de l'Ile Maurice*, p. 25. *Duncan & Sladen*, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pt. v. p. 310, pls. 48, 49.

Syn. *Hipponoe*, Gray, MSS. name, 1840; *Heliechinus*, Girard.

Test moderate to very large, thin, tumid, circular or subpentagonal in outline, broader than high, often subconical, tumid around the peristome; may be depressed and concave around a sunken apical system, with or without depressed interradial median areas abactinally.

Apical system large, madreporite large and in the usual basal plate; some radial plates entering and separating basals; periproct large, its plates numerous, small, tuberculate, and spine-bearing.

Ambulacra very wide, nearly equalling the interradia in breadth, and the widest at the peristome; poriferous zones very broad; the pairs of pores large, triserial, very close vertically and distant horizontally, the inner and the outer rows very persistent and vertical, the middle row somewhat variable in the direction of the pairs of pores; small primary tubercles amongst the series of pairs; the plates very low and numerous, broad, compound; the adoral constituent with the inner pair of pores is a primary plate which is low in the poriferous zone, and occupies all the interporiferous part of the compound plate; the next plate above is a demi-plate with the outer pair of pores, and the upper component is a broad demi-plate with the middle pair of pores. The compound plates may join and two produce a large one, and the primary plate of the upper component may be formed into a demi-plate. Interporiferous areas with several vertical rows of small primary tubercles plain and imperforate.

Interradia with very numerous coronal plates and many, somewhat distant, vertical rows of primary and secondary tubercles resembling those of the ambulacra. More or less bare median areas in the ambulacra, and especially in the interradia abactinally; the angles of the sutures slightly pitted.

Peristome comparatively small, with a tumid surface beyond, the branchial incisions large and long; perignathic girdle with low ridges, and very tall slender oblique processes, uniting largely above; arch large. Jaws high, with a large foramen, teeth keeled. Spines short, sharp, striated. Peristomial membrane with ten large plates and other small ones.

Fossil. Miocene: Europe ?, W. Sind, Asia.

Recent. Gulf of Suez, Red Sea, E. coast of Africa, Mauritius, Rodriguez, Masbate, Philippines, Japan, East Indian Islands, Gulf of California, Caribbean Sea to Bermuda.

Subgenus EVECHINUS, *Verrill* (genus), 1871, *Notes on Radiata*, p. 583; 1871, *Trans. Connect. Acad.* vol. i. no. 8. *A. Agassiz*, 1872–74, *Revision*, p. 502.

Coronal plates moderate in number, the branchial incisions

slight. Few buccal plates. Tubercles rather large, with secondaries; bare median areas slight.

Recent. New Zealand.

Genus incertæ sedis.

The following diagnosis is taken from the description of the solitary species so well described by Agassiz in the Report on the 'Challenger' Echini:—

Genus PRIONECHINUS, *A. Agassiz*, 1879, *Proc. Amer. Acad.* vol. xiv. p. 202; 1881, *Report on 'Challenger' Echini*, p. 109, pls. vi. A. & xl.

Test thin, small, circular in the tumid marginal outline, depressed.

Apical system large and compact; basal plates broad, angular, and with secondary tubercles on their periproctal edge; radial plates large, projecting much beyond the basal plates, pore adoral.

Ambulacra narrow; the poriferous zones rather broad, with two pairs of pores to a plate, in simple vertical series.

Interradia with two vertical rows of large plain tubercles placed near the median suture and sparely distributed granules and small tubercles. Interradia with the coronal plates only slightly higher than those of the ambulacra, a primary tubercle on each about the dimensions of an ambulacral primary, surrounded by some secondary tubercles. Pedicellariæ large-headed.

Spines prominently serrated and rather flat.

Peristome with slight branchial incisions; five pairs of large buccal plates, and only one large tentacle to a pair of plates.

Recent. Philippines and Australia, 700 to 1070 fathoms.

It is impossible to place this genus satisfactorily, so it must remain as *incertæ sedis*.

V.

Order III. The Holectypoida, its Sections and Genera. Order IV. The Clypeastroida, remarks. Family Fibulariidæ and Genera. Family Clypeastridæ and Genera. Family Laganidæ and Genera. Family Scutellidæ, Genera and Subgenera. Subfamily Arachninæ, and Genus.

Order III. HOLECTYPOIDA (p. 25).

Syn. *Galeritidæ* and *Echinoconidæ*, auct. (pars).

This is the first Order of the Exocyclica, and it is a difficult one to classify, for there is much diversity of opinion regarding the nature of the perignathic girdles and jaws of some genera (see p. 22). Some genera have all the other characters of the Order, but research has not decided finally upon the presence or absence of jaws and teeth. In other genera the perignathic girdle is weak, and there are teeth; and in two genera the perignathic girdle forms a strong collar and the interradial portions or "ridges" are wide and bent upwards and outwards from the peristome internally.

The Order may be divided into two sections, and in both the apical system is compact, but the number of the perforate basal plates differs; the madreporite is in the right anterior basal plate, but it may extend back and separate the postero-lateral basal plates. The ambulacra are straight, flush, and apetaloid. The peristome is decagonal or circular, and has branchial incisions often well developed, or the reverse; the peristomial margin is composed of two plates in each ambulacrum, and double plates in each interradium, but the odd area may have a single plate. The periproct is variable in its position in the posterior interradium. Tentacles are restricted to ambulacral plates.

Section I.—The perignathic processes of the ambulacra present.

Genus *Holectypus*.
Pileus.
Pygaster.
Pygastrides.

Section II.—Perignathic girdle with well-developed interradial ridges; ambulacral "processes" rudimentary or absent.

Genus *Discoidea*.
Subgenus *Echinites*.
Genus *Conoclypeus*.

Genera incertæ sedis: *Galeropygus*, *Pachyclypeus*.

Section I.

Genus Holectypus, Desor, 1842, *in Agassiz, Monogr. d'Éch. viv. et foss., Des Galérit.* livr. 3, pp. 52 & 63 (a group of Discoidea). *Desor*, 1858, *Synopsis*, p. 168. *Lovén*, 1874, *Études*, pl. xiv. fig. 124. *Cotteau, Péron et Gauthier*, 1880, *Éch. foss. de l'Algér.* 6 fasc. pl. vi. fig. 7. *De Loriol*, 1888, *Faune Crét. du Portug., Éch.* vol. ii. fasc. 2, p. 69 et seq.

Moderate-sized Urchins with a circular, or slightly pentagonal, tumid ambitus; subconical or depressed dorsally, tumid and more or less hollowed for the central peristome.

Apical system small, central, with five basal plates, the fifth being sometimes small and without a duct-pore; madreporite in basal No. 2, extending centrally and separating the postero-lateral basals.

Ambulacra narrow, straight, widest at the ambitus; pairs of pores in simple series; plates numerous, usually simple, small, low primaries, some plates compound, and a demi-plate often occurs aborally in some compound plates, which carry numerous small primary tubercles. Tubercles, small primaries in many vertical rows.

Interradia with rather large plates, many vertical rows of primaries, larger than those of the ambulacra.

Peristome central, large, decagonal, with well-marked branchial incisions. Pyramids of jaws slender, with a large foramen; teeth slender, grooved (?). Perignathic girdle feeble and not continuous. Periproct large, pyriform, in the posterior interradium between the peristome and the posterior edge of the test; its plates largest posteriorly, smallest near the minute anus anteriorly.

Fossil. Oolites: England, Europe, N. Africa; Cretaceous: Europe, N. Africa, Asia, N. America.

The increase of dimension of the madreporite and the presence of the perforation in the fifth basal are characteristic of the Cretaceous species.

Genus Pileus, *Desor*, 1858, *Synopsis*, p. 167.

Large Urchins, pentagonal in marginal outline, tumid and sub-hemispherical abactinally, more or less flat actinally.

Apical system central, very small, with five basal plates, the fifth imperforate, the madreporite in basal No. 2, and also separating the postero-lateral basals.

Ambulacra long, narrow, straight; primary tubercles very small, without definite order; pairs of pores in simple series abactinally, diplopodous towards the ambitus; plates low primaries, but possibly compound near the ambitus.

Peristome central, decagonal, deeply incised for the branchiæ. Perignathic girdle present (ambulacral processes).

Interradial ornamentation of many scattered rows of small tubercles. Periproct supra-marginal, small, broadly ovoid, opening flush.

Fossil. Oolite: Europe.

It is not a satisfactory genus.

Genus PYGASTER, *Agassiz*, 1839, *Éch. Foss. de la Suisse*, p. 79. *Desor*, 1842, *in Agass. Monogr. d'Éch. viv. et foss.* livr. 3, p. 75. *Desor*, 1858, *Synopsis*, p. 164. *Wright*, 1856, *Pal. Soc. Monogr., Ech. Ool. Form.* p. 273. *Étallon*, *Éch. Haut-Jura, Suppl.* p. 4, *and Lethæa Bruntrutana*, pl. xlv. *Cotteau & Triger*, 1859, *Éch. de la Sarthe*, p. 175, pl. xxx. fig. 16. *Lovén*, 1887 (pub. 1888), *Bih. till Kongl. Svenska Vet.-Akad. Handl.* Bd. 13, Afd. iv. no. 10, p. 8 et seq. pl. ii.

Test large, with a circular or pentagonal, rather sharp ambital outline; subconical and depressed dorsally, more or less truncate behind and concave actinally.

Apical system central or slightly excentric in front, small, with four perforated basal plates; the madreporite large, in basal No. 2, and extending backwards centrally, reaching the widely separated posterior radial plates and the anterior edge of the periproct.

Ambulacra straight, similar, flush or slightly raised, increasing in width to the ambitus and diminishing thence to the peristome; with straight narrow, simple poriferous zones; a pair of pores to a plate, but actinally there are some compound plates, and some fusion of them at the peristome. Tubercles of the interporiferous areas in two or four vertical rows, slightly smaller than those of the interradia, but otherwise similar.

Interradia very broad actinally, with low, broad, curved plates; tubercles in horizontal rows, some continuous vertically, all largest actinally, very regularly placed, perforate and very slightly crenulate or uncrenulate, in flat or depressed areas surrounded with circles, squares, or hexagons of miliaries.

Peristome large, decagonal; branchial incisions large, sometimes

broader than long. Jaws exist. Perignathic girdle with ambulacral processes, discontinuous. Periproct very large or moderate, placed between the apical system and the ambitus of the odd interradium, and at some distance from this; oblong, pyriform or irregular in shape, flush; may be in contact with the apical system, or a portion of the posterior interradium may intervene. Spines short and striated.

Fossil. Oolites: England, Europe. Cretaceous: Europe.

In *Pygaster megastoma*, Wright, the periproct intrudes so much, that the four basals are in a semicircle anteriorly, and the madreporite is not central, but restricted to its normal basal; the posterior radial plates are widely separated. Probably it should enter *Galeropygus*, Cott.

Genus PYGASTREIDES, *Lovén*, 1887, *Bih. till Kongl. Sv. Vet.-Akad. Handl.* Bd. 13, Afd. iv. no. 10, p. 13.

Syn. *Pygaster.*

The periproct is dorsal and posterior.

Ambulacral plates all simple, the first plates broad, uniporous, carrying distinct, separate auricles. Poriferous zones simple, straight. Spheridia single.

Interradial peristomial plates single and broad. Tubercles perforate and crenulate, the primaries the largest. Ornamentation (epistroma) luxuriant.

Recent. Caribbean Sea, near Virgin Islands, 200–300 fms.

The species was founded by Lovén upon one imperfect specimen which only measured 3·5 millim. in length and 2·16 in height. But under the hands of the experienced teacher its structures were described and admirably drawn. The uniporous ambulacra and the solitary interradial plates at the peristome, coupled with weak ambulacral perignathic processes and the anus close to the apical system, characterize the genus, which Lovén has placed among the Echinoconidæ, *auct.* It is a very aberrant form, and the solitary specimen is defective.

Section II.

Genus DISCOIDEA, Klein, 1734 (Discoides), *Nat. Disp. Echin.* p. 26, pl. xiv. Gray, 1825, *Ann. Phil.* p. 429. *Desor*, 1842, *in Agassiz*, *Monogr. d'Éch. viv. et foss.* livr. 3, p. 50. *Desor*, 1858, *Synopsis des Échin. foss.* p. 175. *Cotteau*, 1869, *Ech.*

du Dépt. de la Sarthe, Suppl. p. 412. *Cotteau, Péron et Gauthier*, 1879, *Ech. foss. de l'Algér.* fasc. 8, pl. xii. fig. 2. *Duncan & Sladen*, 1886, *Journ. Linn. Soc.* vol. xx. p. 48. *Lovén*, 1874, *Études*, pl. xiv. fig. 125; 1888, *Bihang till K. Sv. Vet.-Akad. Handl.* Bd. 13, Afd. iv. no. 10, p. 9.

Test moderate and large, circular or subpentagonal in marginal outline, flat actinally, hemispherical or conico-hemispherical above the margin.

Apical system small, subpentagonal, the five basal plates united; the madreporite perforating some or all, genital ducts in all except the posterior; radial plates small.

Ambulacra narrow, flush, except actinally, where they are slightly raised, apetalous, consisting of low primaries near the apex, with rare demi-plates: near the ambitus and actinally there are compound plates, made up of a large middle primary, carrying a tubercle, and an adoral and aboral demi-plate, their sutures convex towards the large primary plate; or a large primary plate is associated with a small adoral demi-plate, the suture being convex abactinally. Pairs of pores very numerous, small, in simple series abactinally, becoming slightly biserial and crowded actinally. Primary tubercles small, crenulated and perforated.

Interradia with distinct median sutures; tubercles small, perforate and crenulate, the vertical rows have larger tubercles near the median line than elsewhere.

Peristome small, funnel-shaped, its margin high up and formed by ambulacral plates and also by a single plate in three interradia, and by a double plate in two interradia. Perignathic girdle a raised oblique discontinuous ring, composed of interradial plates (a ridge), the upper surface flat or shelving.

Interradial plates within the actinal surface with radiating ribs. Periproct small, actinal, between the posterior margin and the peristome, its plates large posteriorly and reaching close to the anal opening. Branchial incisions indistinct.

Fossil. Cretaceous: England, Europe, N. Africa.

The morphology of *Discoidea subuculus*, Klein, necessitates the formation of a subgenus for its reception.

Subgenus Echinites (*non auctorum*).

Test small, tumid actinally and at the margin, subhemispherical above.

Apical system with the madreporite in basal plate No. 2 only.

Ambulacra with greatly crowded low primary tubercles.

Interradia crowded with small tubercles, the line of the transverse coronal sutures furrowed. Ribbing of plates within slight. Perignathic girdle ill developed.

Fossil. Cretaceous: England, Europe.

Genus CONOCLYPEUS, *Agassiz*, 1839, *Éch. Suisse*, vol. i. p. 63. *Desor*, *Synopsis*, 1858, p. 318. *Zittel*, 1879, *Handb. d. Pal.* vol. i. pp. 515–516. *De Loriol*, 1880, *Monogr. des Éch. Numm. de l'Égypte*, p. 80; *Palæontographica*, 1881, *Eocäne Ech. aus Ægypt. u. d. Lib. Wüste*, p. 14. *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pp. 51, 94, 124. *A. Agassiz*, 1883, '*Blake*' *Ech.* p. 49 (*Amended.*)

Test large, thick, more or less oval in marginal outline, conical, vaulted, swollen or subconical dorsally, rather flat actinally, rising somewhat suddenly from the margin.

Apical system central or slightly excentric in front, small, projecting, with four basal plates; the madreporite in the right anterior basal, intruding also on the other basals, occupying the centre of the system, and separating the posterior radial plates; five small radial plates.

Ambulacra long, open, with broad poriferous zones nearly as far as the ambitus, thence gradually diminishing in breadth to the peristome, flush, or slightly sunken, or raised. Plates numerous low and broad primaries, rarely some demi-plates near the peristome. Pores wide apart and in pairs where the zones are broad, the inner pore circular in outline, and the outer more or less elliptical or comma-shaped; pairs gradually increasing in breadth and then diminishing, separated by costæ. Below the parts of the ambulacra with paired pores others are continued to and over the ambitus to the peristome, as a single series, a pair rarely being seen near the peristome and then it is due to the presence of a demi-plate. Phyllodes do not exist. Interporiferous areas broad, often projecting.

Interradia large, but narrow at the summit, and consisting of broad plates which are much higher than those of the ambulacra; projecting into the peristome.

Peristome central, moderate, pentagonal, elongate transversely, with well-marked bourrelets and no phyllodes. A ring-like

perignathic girdle with rather tall interradial ridges and jaws *. Periproct inframarginal, oval and longitudinal.

Ornamentation of the ambulacra similar to that of the interradia, small, very equal, of small perforate and crenulate primaries in sunken scrobicules and intermediate granular epistroma; costæ ornamented.

Fossil. Cretaceous: Europe (?). Eocene: Europe, Africa, Asia †.

Genera incertæ sedis.

Genus GALEROPYGUS, *Cotteau*, 1856, *Bull. Soc. Géol. de France*, sér. 2, vol. xiii. p. 648, & 1858–9, vol. xvi. p. 289.

Syn. *Galeopygus*, Desor, Synopsis, 1858, p. 167; *Centropygus*, Ebray.

Large depressed Urchins, circular at the slightly swollen margin, except posteriorly, where the edge of the test is thin and truncated.

Apical system central, or excentric in front, closed in front and open behind, with four basal plates contiguous and perforated; the madreporite in the usual basal, which is the largest. The anterior and the right antero-lateral radial plates outside, the others in contact with the periproctal groove. A groove containing the periproct entering the apical system and separating the posterior radial plates, the postero-lateral basals, and reaching the left anterior radial plate and the anterior pair of basals. The groove passes down to the posterior truncation, and the periproct is partly within and partly outside the apical system.

Ambulacra narrow, flush, straight, except the postero-lateral, which are more or less curved abactinally. Pairs of pores in simple series. Tuberculation of the test small, rather distant, homogeneous. Peristome central, decagonal, with branchial incisions. Spines subulate, striated, short. Neither perignathic girdle nor jaws have been seen.

Fossil. Oolite: England, Europe.

* A specimen in the British Museum shows the perignathic girdle rubbed down, and a vertical section in another specimen shows the interradial projection or ridge. There is no process connected with an ambulacrum, but the interradial ridges are well developed. The girdle resembles that of *Discoidea* somewhat.

† The genus *Phylloclypeus*, De Loriol, absorbs the old *Conoclypei* with floscelles and no teeth.

Genus PACHYCLYPEUS, *Desor*, 1858, *Synopsis*, p. 198. *Cotteau*, 1867–74, *Pal. Franç.*, *Éch. Terr. Jura*, vol. ix. pl. 101.

Test large, thin, ovoid in marginal outline, tumid above.

Apical system compact?

Ambulacra flush, apetaloid, similar, becoming wider towards the margin and contracting towards the peristome; pairs of pores in simple series.

Peristome central, in a depression, indistinctly decagonal. Periproct supra-marginal and at the posterior surface. Tubercles irregularly distributed.

Fossil. Oolite: Europe.

It is a very unsatisfactory genus and must be placed amongst the doubtful series.

Order IV. CLYPEASTROIDA.

The suborder Clypeastridæ was, as A. Agassiz remarks in his 'Revision of the Echini,' p. 504, limited by his father. The characters of the group are sufficiently determined in the 'Prodrome d'une Monog. des Radiaires,' 1836. But the morphology of the suborder was accurately described by J. Müller in his celebrated work on the structure of the Echinodermata ("Bau d. Echinodermen," Abhandl. d. könig; Akad. d. Wiss. Berlin, pub. 1854, p. 123); and many very important points in the anatomy were also explained by Lovén, in his Études (Kongl. Svenska Vetenskaps-Akad. Handl. Bd. xi. no. 7, 1874, pp. 32 & 47).

Lovén recognized the name given by L. Agassiz and wrote the first perfectly accurate and sufficiently synthetic definition of the suborder (*op. cit.* p. 32). It was evident from the examination of the recent and fossil forms which should come within the suborder that it would have to be split up into divisions of greater or less distinctness, and the types of *Clypeaster*, *Scutella*, *Laganum*, and *Echinocyamus* were noticed to present structural differences of unequal, but still of definite classificatory value. The question arose, were these types to represent families or subfamilies, and if the latter, how many families were to be recognized? A. Agassiz, in his 'Revision of the Echini,' divides the suborder into two families each containing subfamilies, and his first family is Haeckel's Euclypeastridæ (Generelle Morphologie, 1866). The subfamilies were Fibularina, Gray, for *Echinocyamus* and its allies, and the Echinanthinæ for *Clypeasters* (A. Agassiz wrote this last term with the family affix "idæ"). Now

it is certain from the construction of the ambulacra, the nature of the perignathic processes, the development of the internal supports of the tests, and the formation of the apical systems, that there is more than a subfamily distinction to be made between these groups. Again, *Laganum* is the type of a subfamily (Laganidæ, A. Agass.) of the same family Euclypeastridæ, but it departs extremely from the *Fibularina* and the *Echinanthus* of A. Agassiz. The Scutellidæ, the second family, have no subfamilies in the classification of A. Agassiz, yet *Arachnoides* and *Rotula* find a place in it as genera. It appears that the subfamily is made too prominent and at the expense of limiting the family in this classification.

After due consideration it appears that the types of the Clypeastridæ, mentioned above, should be representatives of families, and that the entire group is worthy of the same classificatory value and position as the Endocyclica with jaws. Claus may be taken as a writer having much experience, and in his 'Zoologie' he follows the method of A. Agassiz, but considers his suborder as an Order of the Class Echinides, the Echinodermata as a whole being a Type of Invertebrata.

It seems therefore advisable to call the Order—Clypeastroida, and to partly follow Agassiz and A. Agassiz, by establishing the families Fibulariidæ, Clypeastridæ, and Scutellidæ.

Order IV. CLYPEASTROIDA (p. 25).

Syn. *Clypeastridæ*, Agassiz (suborder), 1836. (Enlarged.)

Test either flat, or tumid, or rising dorsally, with a thin or tumid margin which may be notched; the internal floor and roof connected by calcareous pillars and partitions, limiting more or less the internal organs, and forming, or not, false walls as coverings to the water-system.

The apical system with a central madreporite; basal plates coalesced.

Ambulacra more or less polyporous; tentacles heteropodous. Petaloid parts of the ambulacra both with branchial and disciferous tentacles in the poriferous zones; usually very numerous simple small tentacles, each one in relation with a single pore, in the interporiferous areas, placed in simple or branching grooves, or along the transverse sutures or in the plates generally; tubular branchial tentacles at the peristome.

Interradia smaller than the ambulacra, may be disconnected,

freely perforated by small, single pores for small, simple tentacles actinally, and also more or less abactinally. Tubercles small, perforate, and crenulated. Open spaces or lunules may occur in the extra-petaloid parts of ambulacra and in the posterior interradium*.

Peristome actinal, usually central; interradial marginal plates single; perignathic girdle discontinuous; processes narrow, either interradial or ambulacral. Jaws short, expanded, stellate in dorsal outline, the united pyramids without braces and compasses, projecting over the ambulacral areas; the teeth rarely more or less vertical, mostly horizontal; the jaws resting upon perignathic processes, or having them beyond their re-entering margin; retractor muscles only. Periproct beyond the apical system, excentric, either actinal, marginal, or dorsal in the posterior interradium. Spheridia few, covered.

Family FIBULARIIDÆ.
CLYPEASTRIDÆ.
LAGANIDÆ.
SCUTELLIDÆ.

Family FIBULARIIDÆ, (subfamily) *Gray*, 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 27. (*Amended.*)

Small Clypeastroida with rudimentary, widely open, few-pored petals; jaws rather high; teeth superior and slanting. Perignathic processes broad, low, one on each interradium. Interradia small, with a single apical and a single peristomial plate, continuous*. Periproct usually actinal. Slightly developed vertical partitions within the test, actinally limiting the ambulacra at their sides, radiating towards the peristome. A spheridium in each ambulacrum, covered.

Genus *Echinocyamus*.
Subgenus *Scutellina* (genus), Agassiz.
Genus *Sismondia*.
Fibularia.
Runa.
Moulinsia.
Rotuloidea.

Genus ECHINOCYAMUS, Van Phels. 1774, *Brief.* Leske, 1778, *Addit. ad Klein.* p. 213. *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, p. 125. *A. Agassiz*, 1874, *Revision*, p. 304. *Lovén*, 1874, *Études*, pls. xvi. & xliv.

Test small, thick, pyriform or subcircular in outline, tumid and

* See "Definition of terms," in the last chapter of this 'Revision.'

slightly convex abactinally, concave actinally near the central peristome.

Apical system central; sutures fused; madreporite central, with only one large pore; four genital pores; radial pores variable in size.

Ambulacra broader than the interradia, short where slightly petaloid, widely open distally; pairs of pores few and increasingly far apart; the horizontal sutures beyond the petaloid part, pierced by pores, some pores in the plates near the peristome.

Interradia narrow, continuous, a single broad plate in each, at the peristome and also at the apical end.

Peristome central, pentagonal. Perignathic ridges tall, broad, one on each peristomial interradial plate. Jaws small; pyramids rather high, flat; teeth superior, inclined. Periproct between the peristome and the posterior edge of the test; anal plates four or five, triangular. Ornamentation of uniform small perforate tubercles, carried over the apical system. Spines short and slender. Within the test are five pairs of partitions limiting the ambulacra, for a short distance. A single spheridium in each ambulacrum, covered.

Fossil. Cretaceous to Miocene: Europe. Pliocene: England and Europe. Nummulitic: Asia and Africa.

Recent. N. Atlantic and British Seas, Norway, Azores, Josephine Bank, Mediterranean, Florida, Caribbean Sea. Littoral to 105 fathoms.

Subgenus SCUTELLINA, (genus) *Agassiz*, 1841, *Monogr. d'Ech. viv. et foss.* livr. 2, *Les Scutelles*, p. 98.

Test small, circular in outline. Jaws broad, low; pyramids horizontal; teeth superior. Periproct small, variable, marginal, or more or less supra- or inframarginal.

Fossil. Tertiary: Europe.

Genus SISMONDIA, *Desor*, 1858, *Synopsis*, p. 225. (*Enlarged.*)

Test of small or medium size, subpentagonal or ovoid, depressed, inflated at the margin.

Apical system central or subcentral, flush; only a single pore of the madreporite is present; four basal plates and their pores are large; radial plates small, pores minute.

Ambulacra, petaloid parts usually long, more or less open; pairs of pores few, not continued actinally; a great number of

minute pores occupy the transverse sutures of the plates actinally, and some are in the vertical sutures between the ambulacral and interradial plates. Interradial areas supported internally by a pair of strong, complex, vertical partitions, and the other parts of the test, within, bristle with projections.

Peristome central, sunken or not. Periproct actinal, between the peristome and the posterior margin. Tuberculation minute.

Fossil. Eocene: Europe, Africa, and Asia. Miocene: Europe.

A good series of drawings of a *Sismondia* will be found, by Sladen and Foord, in Monogr. Foss. Ech. Sind, pt. iii. pl. xxv., Pal. Ind. ser. xiv. 1884. They may be compared with the drawings of two species of *Echinocyamus* which are upon the same plate. The *Sismondia* differs in the more definite plating of the apical disk and the longer and more shapeful ambulacra, which are, moreover, tumid. But the alliance is very close. It will be observed that there are several additions to the diagnosis of Desor, in the above definition.

Genus Fibularia, Lamk. 1816, *Hist. Nat. Anim. s. Vert.* vol. iii. p. 17. *Gray*, 1855, *Catal. Rec. Ech. Brit. Mus.* pt. i. p. 28. *A. Agassiz*, 1873, *Revision*, p. 506.

Syn. *Mortonia*, Gray (*non* Desor).

Test small, thin, ovoid or elongate-elliptical, regularly arched and tumid dorsally, or subspherical, tumid at the sides and actinally around the sunken peristome and periproct.

Apical system central; four genital pores.

Ambulacra short, with ill-developed, very open petaloid parts; pairs of pores very few, continued wide apart to the margin, not united by a groove.

Interradia with or without the middle of the plates being raised.

Peristome small, pentagonal, sunken. Minute concentric plates in the peristomial membrane. Jaws high, stout or slender; teeth superior, sloping; perignathic processes large. Periproct actinal, sunken, nearer the peristome than the posterior margin, may be longitudinal and oblong. Internal structure of the test very simple, supports very rudimentary or absent, limiting the ambulacra near the edge. Tuberculation distinct, regular, or more distant actinally.

Fossil. Upper Cretaceous: Europe.

Recent. Mediterranean, Red Sea, Indian Ocean, Japan, Sandwich Islands, Philippines, Australian seas.

The next genus is not a satisfactory one.

Genus RUNA, *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, *Les Scutelles*, p. 32.

Test very small, depressed, faintly arched dorsally, subcircular or ovoid at the thick, deeply incised margin.

Apical system central; four genital pores.

Ambulacra large, separated from the interradia by grooves dorsally and at the margins by incisions; petals short, widely open and everted distally; faint median groove actinally.

Interradia small.

Peristome circular, elliptical, central. Periproct small, between the peristome and the posterior margin.

Fossil. Tertiary: Europe.

A. Agassiz and Lütken consider *Moulinia* = *Moulinsia*, Agassiz, 1841, Monogr. d'Éch. viv. et foss. livr. 2, Les Scutelles, p. 139, tab. 22, to be synonymous with *Encope*, the young forms of this genus greatly resembling the species of *Moulinsia*. But if the figures given by the elder Agassiz be compared with those of A. Agassiz, it will be seen that there is much more general scolloping of the edge of the tests than is seen in the young (supposed) *Encopes*. R. Etheridge described a species from N. Africa which he placed in a genus *Rotuloidea*, and it shows the least possible anterior lobing. Under the circumstances it is best to consider *Moulinsia* and *Rotuloidea* as two closely allied genera.

Genus MOULINSIA (Moulinia), *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, p. 139, tab. 22. *Desor*, 1848, *Synopsis*, p. 222. *Gray*, 1855, *Cat. Rec. Ech. Brit. Mus.* p. 27.

Test small, thin, very depressed, oval, slightly tumid above the edge, but flat dorsally. Margin lobed on account of the grooves along the median lines and between the ambulacra and interradia; some transverse grooving of the coronal plates.

Apical system small, central; five genital pores?

Ambulacra with petaloid parts widely open distally.

Peristome central. Periproct inferior, between the peristome and the posterior margin. Ambulacral pores not united by a groove. Tuberculation very distinct.

Recent. Martinique.

Genus ROTULOIDEA, *R. Etheridge*, 1872, *Quart. Journ. Geol. Soc.* vol. xxviii. p. 98.

Test moderate in size, thick, very depressed, broadly ovoid, longer than broad, actinally slightly concave.

Apical system small, central, circular; madreporite large, central; the genital pores on its flanks.

Ambulacra subpetaloid, widely open, with rather broad poriferous zones; inner pores circular, outer elongate; and more or less tumid interporiferous areas; actinally five perforated furrows, ramifying towards the margin.

The interradia larger than the ambulacra.

Anterior margin of the test smooth and slightly acute; posterior margin broader and with many (12) fimbriations continued actinally as grooves. Neither lunules nor cuts.

Peristome central, pentagonal, sunken. Periproct small, between the peristome and the posterior margin. Tubercles equal, densely placed in areolæ.

Fossil. Miocene: N. Africa.

Family CLYPEASTRIDÆ.

Syn. *Echinanthidæ* (subfamily), A. Agassiz, 1872–74, Revision, p. 510.

Test small to very large, depressed, flat, to high; margin subpentagonal or subcircular, sharp to very tumid. Apical system central, the basal plates fused together, all perforated by the central madreporite; genital pores beyond. Petaloid parts of the ambulacra highly developed, usually unequal, the actinal furrows straight.

Interradia actinally discontinuous, one peristomial and two apical plates in each. Jaws large, tall, wide above, the teeth in vertical grooves on the inner part of the pyramids. Perignathic processes tall, narrow, two on each ambulacrum, fitting in below the jaws. Internal structure various, always with needles and pillars extending from floor to roof and expanding, placed so as to limit the ambulacra incompletely from the intestinal areas, extending considerably towards the peristome; there may or not be a development of the pillars close to the edge of the test, and a more or less complete fusion of them into partitions arranged concentrically, so as to form inner walls; there may be an inner wall to the ambulacra protecting and

forming the canals for the water-system; actinally the ambulacra and interradia much pierced by pores, less so dorsally. Tentacles heteropodous. Spheridia two, covered, in each ambulacrum.

Genus *Clypeaster*.
Subgenus *Monostychia*.
Genus *Diplothecanthus*.
Plesianthus.
Anomalanthus.

The generic name *Clypeaster* originated with Lamarck, Syst. Anim. s. Vert. 1801. Previously Breynius, 1732, 'Schediasma de Echinis Methodica disponendis,' p. 59, placed a genus *Echinanthus* as one of the seven into which the Echinoidea could be divided. His definition was, "*Echinanthus* est Echinus cujus apertura pro ore est prope centrum, pro ano in, vel ad marginem longissime ab ore distantem." This is completely inadequate, and it naturally led him to combine several forms within the group, which really have no generic resemblance or affinity. Breynius gave figures of his types, and it is perfectly evident that his first form of *Echinanthus* is a well-grown *Echinolampas oviformis*. (This was reproduced in after years by Klein, Nat. Disp. Ech. tab. xx. figs. *c–d*; compare with Breynius, tab. iv. fig. 1.)

A second form included resembles *Pygorhynchus*, and a third is a *Cassidulus*. Breynius gave no figure of a *Clypeaster* or of an *Echinanthus* as accepted by modern naturalists; but he refers to Rumphius, 1705, 'Amboinsche Rariteitkamer,' pl. lix. fig. D, stating that his figure of *Echinanthus* agrees with the type of Rumphius; but this last is a miserable figure of a fossil *Clypeaster altus*. Again, the figure in Rumphius's tab. xiv. fig. 3, is said by Breynius to represent an *Echinanthus*, but it is a Cassiduloid. However, Breynius refers to Sloane, Nat. Hist. Jamaica, t. ii. tab. 242. figs. 6–11, and states that the figures also relate to his *Echinanthus*. They are those of the tumid Clypeastroid. It is interesting to note that Breynius remarked that the teeth of this form differ from those of *Echinometra*, and that there are within the test "trabes perpendiculariter erectas."

It is clear that Breynius did not separate the toothless *Echinolampas* and Cassiduloids from the gnathostomous Clypeastroid. It is therefore useless to prolong the discussion regarding his priority.

Klein came next, and although he employed the figures of Breynius and added, *op. cit.* pl. xxix., capital figures of the supports

and double ambulacral floors of the tumid Clypeastroid, he did not employ the term *Echinanthus*. On the contrary, he called the forms (Nat. Disp. Ech. p. 28, pls. 17 *a*, 18 *b*, 19 *a*) Sectio "Scutum," species *humile* and *altum*.

Linnæus called the tumid Clypeastroid *Echinus reticulatus*; and Lamarck clearly differentiated the genus *Clypeaster* and included both the tumid and the flatter species in it.

Neither of these last-mentioned naturalists considered the genus *Echinanthus* of Breynius to be of any value.

In 1825 Gray resuscitated the term *Echinanthus*, but applied it not after the meaning of Breynius; he made it include the species termed *Clypeaster* by Lamarck. Neither Desmoulins nor Agassiz and Desor followed Gray, but considered Lamarck's generic term good and correct. However, in 1855 Gray called all Clypeastroids, both flat and tumid, "*Echinanthus*," in his Cat. Recent Ech. Brit. Mus.

In 1825 Gray had founded the genus *Echinolampas*, and in the Catalogue just referred to, p. 35, he again diagnosed that genus, and placed *Echinanthus* (see also under *Echinolampas oviformis*, Cat. Rec. Ech. Brit. Mus. p. 35) as a synonym. Here an error crept in, and palæontologists and zoologists have ever since employed *Echinanthus* in a different sense. The palæontologists, following the early part of the definitions of *Echinanthus* by Breynius, have associated the word with the Cassidulidæ; the zoologists have either associated the word with all the Clypeastroids, or have used it, following A. Agassiz, for the tumid Clypeasters especially.

Desor, in his Synopsis, 1858, associated the term *Echinanthus* with a well-differentiated group, having all the characters of that figure given by Breynius which has a *longitudinally elongate periproct placed supramarginal*—the figure which may have represented a *Pygorhynchus*. *Echinanthus* of Desor is a large genus, and it is impossible to state, with truth, that it is not *Echinanthus* according to Breynius.

The distinction between the internal construction of the flat and the concave based or tumid Clypeasters was shown by J. Müller in his 'Bau d. Echin.' 1854, p. 123. A. Agassiz, in his 'Revision,' was so struck with the value of J. Müller's discoveries, that he determined to make the tumid Clypeasters form a genus *Echinanthus*, which he attributed to Breynius. The whole subject is considered with the usual great care of the author of that 'Revision,'

and it does not appear that he will do otherwise than hold his ground.

A. Agassiz retains the Lamarckian name *Clypeaster* for the flat-based and more or less thin-edged Clypeasters, and it becomes of great importance to discover whether the internal structures of the tumid form are sufficient to necessitate its inclusion in a different genus.

This question was carefully considered before the publication of this Revision, and with the result that *Clypeaster* must remain as a genus, and that two genera must be founded, one to include the West-Indian *Clypeaster reticulatus*, Linn. sp. (*Echinanthus rosaceus*, A. Agassiz), and the other to be associated with *Echinanthus testudinarius*, Gray, from Australia.

Anomalanthus, Bell, is a fourth genus closely allied to *Clypeaster*.

It will be observed that *Echinanthus* is now removed from the Clypeastridæ and is placed amongst the Cassidulidæ, where Breynius certainly meant it to be in the first instance.

Genus Clypeaster, Lamk. 1816, pars, *Hist. Nat. Anim. s. Vert.* vol. iii. p. 12. *Desor*, 1858, *Synopsis*, p. 299. *Lütken*, 1863 (pub. 1864), *Vid. Medd. f. Nat. For. i Kjöbenh.* pp. 100, 132. *A. Agassiz*, 1872–74, *Revision*, p. 306. *Duncan*, 1885, *Journ. Linn. Soc., Zool.* vol. xix. p. 203, pl. 31. *Lovén*, 1887, *Ech. descr. by Linnæus*, pp. 171–176 (for synonymy).

Test variable in size, moderate to large, subpentagonal, ovoid, subcircular in marginal outline, usually truncated behind; edge thin, rarely slightly swollen, undulating in contour, with or without re-entering angles. Dorsum very depressed or tall, conical or subconical, or campanulate, and usually tumid centrally, and sloping to the margins. Actinal surface flat, and with the central peristome suddenly deeply sunken.

Apical system small, central, or slightly excentric; madreporite central, button or star-shaped; basal plates fused; genital pores close to the edge of the madreporite, or in the median interradial sutures, five in number; radial plates small, and the pores also.

Ambulacra much larger than the interradia, the petals large, broad, long, tumid; poriferous zones broad, inclined, or narrow and short, nearly closing distally; plates low, broad, unsymmetrical, compound; the adoral component a primary and the aboral a low broad demi-plate; pores unequal, wide apart, with an intermediate groove; pores in the transverse sutures of the

tumid interporiferous areas. Beyond the petals and actinally, the pores are numerous and are oblique.

Small pores in great numbers in oblique transverse lines in the plates, to the peristome; actinal grooves straight, more or less developed, perforated. The second ambulacral plates from the peristome large and uniting around, so as to intrude upon the interradia.

Interradia narrow between the petals, the double apical plates may have a genital pore in their median sutures; a single plate at the peristomial margin; discontinuous actinally. Pores perforating the plates slightly abactinally and considerably actinally.

Peristome sunken, polygonal, thin-edged, with ten ambulacral and five interradial plates; buccal pores at the edge; two spheridia hidden in each ambulacrum. Perignathic girdle discontinuous, placed beneath the jaws; the processes tall, narrow, close, in pairs, arising from the edges of ambulacral plates. Jaws large; pyramids unequal, expanded dorsally; teeth in more or less vertical grooves placed on their inner surface; depressions below the pyramids for the articulation of the perignathic processes. Periproct infra-marginal, near or at the edge, posteriorly.

Within, numerous concentric partitions near the edge of the test, forming false walls, composed of fused or perfect needle-shaped or stout pillars expanding at the roof and floor; around the distal part of the petals and reaching to the floor are needles and supports expanding above and below, shutting off, incompletely, the ambulacral from the intestinal areas; this structure may extend some distance between the petals. The ambulacral plates with projecting ridges or needles, not coalescing to cover over the water-system or to form a double wall.

Tentacles of the petaloid part of the poriferous zones branchial and pectinated in whorls; the tentacles of the small pores prehensile, with a calcareous support to the disk. Pedicellariæ, some large stout-headed and narrow-ended tridactyles upon short calcareous stems; other pedicellariæ long, with narrow valves, or gemmiform and upon longer stems. Tubercles small, largest actinally, in sunken scrobicules, the intermediate structure with miliaries; ambulacral ornamentation smallest.

Spines very short for the size of the test, fine, cylindrical, largest and sometimes spathiform actinally.

Fossil. Tertiary: Europe, Africa, Asia, Australia, and N. America.

Recent. Red Sea, East-Indian Islands, New Caledonia, Philippines, Japan, Kingsmill Is., China Sea, Panama, San Diego, West coast of Africa, S. Carolina, Florida, Caribbean Sea, Brazil.

The huge, tall, bulky Tertiary species have flat actinal surfaces and are true Clypeasters. *C. altus* and *C. ægyptiacus* have short stout ridges upon the ambulacral plates of the petals, within the test, and they do not coalesce, or do so very imperfectly in places.

Subgenus Monostychia, (genus) *Laube*, 1869, *Sitz. d. kais. Akad. d. Wiss. Wien*, p. 188; (genus) *Duncan*, 1887, *Quart. Journ. Geol. Soc.* vol. xliii. p. 417.

Test small, flat.

Apical system small; madreporite button-shaped; four genital pores; margin notched when young decidedly, and the peristomial ambulacral grooves straight and continued abactinally.

Fossil. Tertiary: Australia.

Genus Diplothecanthus.

Syn. *Echinanthus*, Breynius, 1732, pars; Leske, 1778, pars; Linnæus, 1764, Mus. Lud. Ulrich. p. 714 (*Echinus reticulatus*, see Lovén, 1887, Ech. descr. by Linnæus, p. 174); J. Müller, 1853, Bau d. Echin., Abhandl. d. könig. Akad. d. Wiss. zu Berlin, pub. 1854, p. 123; Gray, 1855, pars; A. Agassiz, 1872–74, Revision, p. 310.

Test moderate and large, pentagonal or subcircular in tumid marginal outline, angles rounded; dorsum tumid variably; actinal surface tumid, but hollow from the margin to a deep central peristome.

Apical system small, madreporite star-shaped, central; the small radial plates at the re-entering angles, pores small, usually transverse; the basal plates fused; genital pores in the median sutures of the interradia, more or less remote.

Ambulacra with long, broad, tumid, almost closed petaloid parts, with the poriferous zones broad, slanting or depressed; the pores distant, unequal; the plates compound, the adoral component a large low primary, the aboral a small demi-plate; the wide interporiferous areas perforated; beyond the petals the plates are simple and larger, and are mainly perforated obliquely actinally.

The interradia small abactinally and sunken; discontinuous actinally, one plate entering the peristomial margin in each.

Peristome deep, its margin composed of ten ambulacral and five interradial plates, two spheridia in each ambulacrum hidden. Straight grooves in the ambulacra, and buccal pores at the margin of the peristome. Teeth, jaws, and perignathic girdle as in *Clypeaster*. Periproct at or close to the margin.

Internal structure without concentric partitions or false walls at the edge, or separate needles, expanded above and below near the edge, but with the petaloid parts of the ambulacra more or less limited by stout discontinuous septa or pillars which extend some way towards the apex, and are curved around the poriferous zones; the ambulacral and intestinal areas imperfectly separated. The ambulacra, with the exception of the poriferous zones, have an inner wall, produced by the coalescence of broad calcareous growths from the inner surface of the plates remote from their transverse sutures, and which, after reaching a certain height, expand and unite so as to form a wall standing upon low broad foundations; the raised foundations bound, and with the expansion form, the canals for the main and secondary water-systems of the ambulacra; foramina occur along the median line and near the poriferous zones. This inner wall supports expansions of pillars and needles.

Ornamentation small; tubercles sunken and surrounded with miliaries. Spines short, slender. Pedicellariæ, some very large, tridactyle and tumid-headed. Two hidden spheridia in each ambulacrum.

Fossil. Tertiary: West Indian Islands (Anguilla); San Domingo.

Recent. West Indian Islands, Florida. (Littoral to 5 fathoms.)

Genus PLESIANTHUS.

Syn. *Clypeaster*, Lamk. (pars); *Echinanthus*, Gray, 1855, A. Agass. 1872–4, pars.

Test with a tumid, subpentagonal margin, tumid and depressed dorsally, concave actinally; peristome deeply seated.

Apical system with a button- or star-shaped central madreporite; basal plates fused; genital pore beyond and in the median suture of the interradium; radial plates very small, pore circular or elongate.

Ambulacra with the petaloid parts long, tumid, broad, closed, or nearly so; poriferous zone broad, sloping or depressed, pores unequal, distant; plates compound, the adoral component a

primary, the aboral a small demi-plate; interporiferous areas broad, perforated. Pores of the non-petaloid parts oblique.

Interradia small, discontinuous actinally, more or less perforated, grooved or not. Peristome with ten ambulacral and five interradial plates, two hidden spheridia in each ambulacrum. Jaws and perignathic girdle as in *Clypeaster*. Periproct inframarginal, in or close to the edge.

Internal structure with tall pillars, more or less united, and expanding at the roof and floor, placed so as to bound the ambulacra incompletely, and to reach some distance towards the centre of the test; some needles. Concentric partitions absent near the edge, and the inner wall of the ambulacra also.

Spines small, cylindrical, largest actinally, and sometimes spatulate.

Recent. Japan, Red Sea, Sandwich Islands, La Paz, Australia.

Plesianthus (=*Echinanthus*) *testudinarius*, Gray, sp., is the type.

Genus Anomalanthus, *J. Bell*, 1884, *Proc. Zool. Soc. Lond.* p. 40.

Syn. *Echinanthus*, A. Agass. 1872–74, pars (see Rev. T. Woods, 1877–1878, Proc. Linn. Soc. N.S.W. vol. ii. p. 169).

Test large, ovoid in tumid marginal outline, high, swollen, flattened near the apex, which is slightly anterior. Peristome deeply sunken, grooves very slight.

Madreporite central, star-shaped; genital and radial pores variable in size.

Ambulacra apetalous, the poriferous zones abactinally broad, increasing in breadth to close to the margin, diverging gradually and becoming very wide apart, even tending to the lyrate form; pairs of pores very diverse in size, united by shallow grooves.

Periproct elongated transversely at the ambitus.

Recent. Australia.

It is interesting that there should only have been one large and mutilated specimen of the species "*tumidus*," Woods, but Prof. J. Bell made the most of his opportunity. There is a true *Clypeaster* in the Eocene of Kutch (Kachh) which has lyrate-shaped semi-petals (Duncan and Sladen, 1883, Monogr. Tert. Ech. Kachh and Kattywar, Pal. Indica, ser. xiv. p. 11).

Family LAGANIDÆ, (subfamily) *A. Agassiz*, *Revision*, 1872–74, p. 516. (*Enlarged.*)

Test flat, with swollen or thin edges; the petals more or less unequal, narrow, lanceolate, moderate in length, ambulacra beyond them very wide; pairs of pores for branchial tentacles few, and between them are minute pores for prehensile tentacles, of which there are also multitudes in the interporiferous areas. Interradia small, each with a single apical and peristomial plate, continuous. Simple straight actinal grooves in the ambulacra, perforated, and with a buccal process and buccal pores. Periproct between the peristome and the posterior margin. Jaws small, rather high, the teeth superior and slanting. Perignathic processes (ridges) single on the interradial peristomial plates, situated so as to be beyond and not below the jaws. Internal structure of several pillars forming discontinuous concentric partitions close to the edge of the test, and of partitions limiting the ambulacra.

It is proposed to absorb the genus *Rumphia* and the subgenus *Peronella*.

Genus *Laganum*.

Genus LAGANUM, *Klein*, 1734, *Nat. Disp. Ech.* edit. Paris, 1754, p. 92. *Gray*, 1825 (Lagana), *Ann. Phil.* n. s. vol. x. p. 427. *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, *Les Scutelles*, p. 105. *Gray*, 1856, *Cat. Rec. Ech. Brit. Mus.* p. 8. *A. Agassiz*, 1873, *Revision*, p. 516. *Lovén*, *Études*, 1874, pp. 47, 83. *J. Bell*, 1883, *Ann. Mag. Nat. Hist.* vol. xi. ser. 5, p. 130. *Duncan*, 1885, *Journ. Linn. Soc.*, *Zool.* vol. xix. p. 206, pl. 31. (*Amended.*)

Syn. *Rumphia*, Desor, 1858; *Polyaster*, Michelin; *Michelinia*, Duj.; *Peronella*, A. Agassiz.

Test moderate in size and large; subpentagonal or ovoid at the swollen or thin margin, truncated posteriorly, longer than broad, very depressed dorsally, flat or slightly concave actinally.

Apical system small, more or less stellate; madreporite central, with or without a curved furrow, into which enter a few water-pores; genital pores four or five, upon the flanks of the madreporite.

Ambulacra much larger than the interradia, but with the petaloid parts rather narrow, moderately long, nearly closed distally, plates simple; poriferous zones with minute simple pores in a transverse row between the consecutive large pairs;

interporiferous areas with very numerous transverse rows of pores for minute tentacles; actinally and at the peristome is a short groove, straight and perforate; buccal pores large. A single spheridium, covered, in each ambulacrum.

Interradia narrow; abactinally the highest plate is single, and actinally the plates are continuous, and the peristomial plate is single.

Peristome small, central, polygonal, formed by ten ambulacral and five interradial plates. Jaws well developed, with the teeth superior and more or less inclined. Perignathic processes single; interradial, short, bent, placed beyond the limits of the pyramids.

Periproct small, inframarginal.

Pillars and partitions only in concentric parallel series near the edge, within the test. Tubercles and surrounding miliaries scattered, similar, usually largest actinally. Spines short, dorsally cylindrical, slightly swollen, larger, longer, and cylindrical actinally, many around the peristome and periproct. Large slender tridactyle pedicellariæ near the petaloid parts of the ambulacra; others with expanded tops on projecting stalks very general.

Fossil. Tertiary: Europe, Asia, Java, N. Africa (Egypt), N. America.

Recent. East Indian Islands, Philippines, Pacific Islands, Japan, Persian Gulf, Red Sea, Mauritius, Zanzibar, Australia, Tasmania, New Zealand.

Family SCUTELLIDÆ, *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, p. 1. *A. Agassiz*, 1872–74, *Revision*, p. 524.

Test very flat, margin incised or not, lunules or slits in the areæ or not. Ambulacral furrows bifurcating and branching. Peristome flush. Jaws flat, teeth superior. Radiating partitions between the floors internally.

Genus *Scutella.*
  Subgenus *Echinarachnius.*
Genus *Echinodiscus.*
  Encope.
  Subgenus *Monophora.*
Genus *Mellita.*
  Subgenus *Mellitella.*
    Astriclypeus.
Genus *Lenita.*
  Mortonia.
  Rotul .

Subfamily *Arachninæ.*

Ambulacral petals diverging; actinal grooves straight; no marginal cuts or lunules.

Genus *Arachnoides.*

Genus SCUTELLA, Lamarck, 1816, *Hist. Nat. Anim. s. Vert.* vol. iii. p. 7. *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, *Les Scutelles*, p. 75.

Test moderate and large, much depressed, circular or subcircular in outline, or undulating slightly or notched, broadest posteriorly, dorsally tumid, or subconical centrally, sloping to the thin edge.

Apical system central, more or less pentagonal; madreporite central; four genital pores at the edge of the projections; small radial plates and pores.

Ambulacra with the petaloid parts unequal, well developed, nearly closed; poriferous zones very broad, the inner pore large, the outer very small, and intermediate simple pores in the connecting groove; actinal grooves straight and deep near the peristome, bifurcating much beyond.

Peristome central, subcircular; buccal processes projecting. Jaws low, with rising laminæ on either side of the superior horizontal teeth; pyramids unequal. Periproct small, inframarginal. A homogeneous ornamentation of tubercles in hexagonal areas which are crowded with miliaries, largest actinally.

Within the test, flat pillars and partitions, forming discontinuous structures concentrically near the edge, and limiting the ambulacra for short distances.

Fossil. Cretaceous?: N. America. Eocene, Miocene, and Pliocene: Europe.

Subgenus ECHINARACHNIUS, Leske (genus), 1778, *Addit. ad Klein*, p. 218. *Gray*, 1825, *Annals of Phil.* vol. x. p. 6 (genus). *E. v. Martens*, 1865 (Scutella), *Monatsb. d. könig. Akad. d. Wiss. Berlin*, p. 140. *A. Agassiz*, 1872–74, *Revision*, p. 315 (subgenus). *Lovén*, 1874, *Études*, p. 50.

Syn. *Dendraster*, Ag.; *Scaphechinus*, Barn.; *Chætodiscus*, Lütk.

Apical system excentric in front or behind.

Ambulacral petals large, long, unequal, open or tending to close; poriferous zones broad; pores and prehensile tentacles in the zone between the branchial tentacles; actinal furrows simple, narrow, and perforated near the peristome, bifurcating and

branching further out; the median furrow continues to the margin and may also be abactinal.

Interradia narrow, but the two apical plates do not embrace the genital pores, which are on the flanks of the madreporite; actinally the posterior interradium is discontinuous in the adult. Perignathic processes single, upon an interradial peristomial plate.

Peristome central, its margin composed of ten ambulacral and five interradial plates; buccal tentacles large, simple.

Periproct actinal, marginal or supramarginal. Marginal pedicellariæ bifid. A single covered spheridium in each ambulacrum.

Internal structures close, broad, concentric, discontinuous partitions and pillars, which radiate from points and occupy much space near the inner edge; more or less continuous partitions limiting the ambulacra for some distance inwards.

Recent. Both sides of N. America, Japan, Kamtschatka, Australia, New Zealand, Indian Ocean, Red Sea.

Genus Echinodiscus, Breynius, 1732, *Schediasma*, p. 63, tab. vii. (pars). *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, pp. 62, 72; *Gray*, 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 19. *A. Agassiz*, 1873, *Revision*, p. 531.

Syn. *Amphiope*, Agass., 1841; *Lobophora*, Agass., 1841.

Test moderate and large, thin, flat, slightly raised dorsally, subcircular, widest posteriorly and truncated there. Two lunules or slits posteriorly, one in each of the median lines of the postero-lateral ambulacra; lunules long, narrow, or broad and circular.

Apical system central or slightly anterior. Madreporite central, large, stellate; four genital pores beyond; radial plates small. Ambulacral petals small, broad, unequal, closed; the poriferous zones very broad; actinally the grooves are single near the peristome, perforate, wavy, and they soon bifurcate and again near the margin; a buccal process in each groove near the peristome.

Interradia narrow, the two apical plates of each having a genital pore in their median suture.

Peristome small, central, lobed or subpentagonal. Jaws flat, stellate, teeth horizontal, placed above the perignathic processes, which are single in each interradium and low and oblique. Periproct small, actinal, nearer the posterior edge of the test than the peristome.

Internal structure with the central space free, and beyond to the inner edge there are stellate networks of cellular supports

and of pillars. Actinal tubercles larger than the abactinal and the spines also, those of the dorsum are clavate.

Fossil. Tertiary: Europe, Africa, Asia.

Recent. Japan, E. coast of Africa, Red Sea, Madagascar, Java, Philippines, New Caledonia.

Genus ENCOPE, *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, *Les Scutelles*, p. 45. *Michelin*, 1851, *Rev. et Mag. Zool. France*, p. 99. *Lütken*, 1863 (pub. 1864), *Vid. Medd. f. Nat. For. Kjöbenh.* pp. 111 and 133. *Verrill*, 1867, *Notes on Radiata*, p. 309. *A. Agassiz*, 1872–4, *Revision*, pp. 126, 324, 544. *Lovén*, 1874, *Études*, p. 47.

Test moderate and large, very depressed, slightly arched dorsally, flat actinally; marginal outline variable, circular, elliptical, ovoid or subpentagonal, may be broader than long or the reverse, more or less truncated behind. A broad notch of greater or less length, or a lunule in the median lines of the ambulacra, and a lunule in the posterior interradium.

Apical system central, or excentric in front; madreporite more or less stellate in outline, the five genital pores outside of it; the radial plates small and the pores minute on its sides.

Ambulacra divisible into a bivium and trivium; the posterior petaloid parts the longest, very nearly closing, with very broad poriferous zones; inner pores large, others small in very narrow grooves. Actinally the ambulacral grooves are perforated, bifurcating and branching towards the margin. The second ambulacral plates of all the zones are large, and unite so as to form a ring around the peristome, which is composed of ten small ambulacral plates and five interradial plates.

Interradia very narrow abactinally, the highest pair of plates narrow and including the genital pore in the median suture; actinally discontinuous, a single peristomial plate to each area.

Peristome small, subpentagonal; a single half-hidden spheridium in each ambulacrum. Periproct small, between the posterior lunule and the peristome, or entering the lunule.

Inside, the test is very cellular, and there is a more or less continuous area with pillars and partitions, some concentric or radiating from many points near the edge within; cellular structure separating the poriferous zones of the ambulacra from the intestinal tract and reaching inwards; a corresponding structure becoming lamellar in the interporiferous areas, and another surrounding the jaws.

Jaws small, stellate; teeth superior. Perignathic processes one on each interradium, low, narrow, bent. Spines short and cylindrical actinally, very small and ovate-headed dorsally.

Fossil. Miocene: Cuba.

Recent. W. coast of America, California, West Indies, Yucatan, Panama, Florida.

Subgenus Monophora, *Agassiz*, 1847 (genus), *Bull. Soc. Géol. de France*, vol. iv. p. 287. *Cotteau*, 1884, *Bull. Soc. Zool. de France*, vol. ix. p. 340, pl. xi. *A. Agassiz*, 1874 (subgenus), *Ech. 'Hassler' Exped.*, *Ill. Cat. Mus. Comp. Zoöl.* no. 8 (1), p. 13.

Test moderate in size, discoidal, with a thin, subcircular or slightly lobed margin, may be widest posteriorly; tumid dorsally, flat actinally. A single small lunule in the posterior median line.

Apical system central; madreporite large, genital pores on its flanks.

Ambulacra with nearly equal petals, which are short and nearly closed distally; poriferous zones broad; pores of pairs unequal, distant, separated by a long flexuous groove; beyond the petals the pores diverge and penetrate the wide ambulacral plates. Actinally, the ambulacral grooves are straight at the peristome and perforated, they soon bifurcate and may ramify further out.

Interradia narrow near the apical system, smaller than the ambulacra, the posterior with a small oval oblong lunule in the line of its median suture.

Peristome subcircular. Periproct small, not far from the peristome, and between it and the lunule. Tubercles abundant, close, small, smallest on the flanks of the ambulacral grooves.

Fossil. Miocene: Haut Parana and Patagonia, South America.

Genus Mellita, Klein, 1734, *Nat. Disp. Ech.* p. 31, pl. xxi. (ed. Paris, 1754, p. 90, tab. xi. fig. *c*). *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, p. 34. *Gray*, 1851, *Proc. Zool. Soc.* p. 36. *Michelin*, 1858, *Rev. et Mag. Zool.* p. 358. *Verrill*, 1867, *Notes on Radiata*, p. 312, and 1871, p. 588. *A. Agassiz*, 1872–4, *Revision*, pp. 140, 319, and 534.

Test moderate and large, very flat, slightly arched above, especially anteriorly, slightly concave actinally, edge rather sharp.

Marginal contour variable, subcircular, subpentagonal, narrow and long or the reverse, usually truncated posteriorly. Five or six lunules, usually closed, narrow and long, one in the median line of the posterior interradium, the others in the ambulacra, rarely developed as cuts.

Apical system variable in position, central or excentric in front, large, the madreporite central, the radial plates on its flanks, the four genital pores in the interradia.

Ambulacra petaloid abactinally, the posterior pair the longest, all nearly closed, with broad poriferous zones, pores distant; interporiferous areas tumid, plates very low. Actinally the plates are grooved simply and perforated near the peristome, the grooves bifurcate more than once towards the edge of the test. A single half-hidden spheridium in each groove near the peristome.

Interradia very narrow abactinally, the apically placed plates enclosing a genital pore in four areas; discontinuous actinally except in the posterior interradium.

Peristome small, central or excentric in front, with an ornamented margin; single interradial perignathic processes, short, curved, bent backwards. Jaws above the processes, rather flat; teeth superior. Periproct small, at the proximal end of the interradial lunule.

Simple pillars and close radiating partitions connect the upper and lower surfaces of the test near the edge inside, and extend inwards as solid partitions and separate the ambulacral and intestinal areas, and a cellular structure limits the jaws more or less. Spines club-shaped abactinally, spathiform near the edges of the lunules, actinally straight and long, and cylindrical and curved near the ambulacral furrows. Actinal tubercles rather large, with a raised warty intervening structure, abactinal tubercles smallest.

Fossil. Pliocene and Post-Pliocene: N. America.

Recent. Gulf of California, Panama to Peru, Galapagos, West Indies, N. and S. Carolina, Florida, Bermuda, Brazil; (Red Sea?).

Subgenus MELLITELLA.

All the ambulacral lunules as open slits in the margin. Genital pores four in number. Peristome and apical system excentric posteriorly.

Recent. Guayaquil, Panama, Galapagos.

To receive *Mellita Stokesi*, Agass., sp.

Subgenus ASTRICLYPEUS, *Verrill*, 1867 (genus), *Notes on Radiata*, p. 311. *A. Agassiz*, 1873, *Revision*, p. 538.

Syn. *Crustulum*, Troschel.

Test large, stout, depressed, circular in front, truncated posteriorly. Petals slightly unequal; poriferous zones broadest at the distal ends of the petals. Lunules long, narrow, the anterior the longest, all ambulacral; the interradial lunule wanting. The calcareous pillars separating the jaws from the intestinal region absent. Remaining internal structure as in *Mellita*.

Jaws flat, pitted inferiorly for the articulating processes of the girdle; teeth superior, short.

Recent. China and Japan.

Genus LENITA, *Desor*, 1847, *Catal. Rais.* p. 84; 1858, *Synopsis*, p. 222. *E. Forbes*, 1852, *Quart. Journ. Geol. Soc.* p. 342.

Test elongate, elliptical, depressed, only slightly tumid dorsally. Apical system with four genital pores.

Ambulacra with open petals; the pores barely conjugate.

Peristome circular, central. Periproct supramarginal. A broad, smooth antero-posterior actinal zone along the median line, flanked by large tubercles. Pillars and septa absent within.

Fossil. Eocene: Europe.

The next genus is of very doubtful value.

Genus MORTONIA, *Desor*, 1857, *Synopsis*, p. 231.

Test moderate in size, circular in outline, with a swollen edge.

Apical system with five genital pores. Ambulacral petals open.

Peristome central, and the periproct between it and the posterior margin of the test. Ambulacral grooves actinally dichotomizing and branching.

Fossil. Eocene: Alabama, N. America.

Genus ROTULA, Klein, 1734, *Nat. Disp. Ech.* p. 31, pl. 22 (ed. Paris, 1754, p. 94). *Agassiz*, 1841, *Monogr. d'Ech. viv. et foss.* livr. 2, *Les Scutelles*, p. 23. *Gray*, 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 16. *A. Agassiz*, 1873, *Revision*, p. 540. *Lovén*, *Études*, 1874, pp. 33, 83, pl. 46. fig. 238.

Test moderate and small, very flat, circular anteriorly, with

several short digitations, varying in length at the sides and posteriorly, with or without incisions, and two anterior lunules; slightly tumid dorsally, and flat or concave actinally.

Apical system small, central, tumid, stellate or not; radial plates small and with minute pores at the end of the limbs of the star; the four large genital pores within the system, rather close and separated by part of the madreporite or in grooves. Madreporite central and extending outwards; sutures not visible; fifth genital pore absent.

Ambulacra well developed, subequal, but divisible into bivium and trivium, long, subpetaloid, open distally, where the pores diverge and are continued irregularly to the margin; poriferous zones broad; pores large, except quite apically, with or without a line of intermediate minute perforations. In well-defined grooves at the peristome, perforated minutely, ending in a peristomial projection where there are large pores, grooves bifurcate into the digitations or not and in front. Spheridia, one in each peristomial groove, half covered.

Interradia very narrow at the apex and with one plate there; disconnected actinally, except in the posterior area and sometimes in area 3, on account of the dimensions of plates 2 of the ambulacra external to the peristomial series.

Peristome small, central, subpentagonal, with five slightly projecting ambulacral processes, surrounded by ambulacral and interradial plates.

Jaws short, small; teeth superior; perignathic processes interradial, single, small, low, hollow towards the pyramids.

Periproct small, circular, between the peristome and the digitations. Tubercles of the actinal surface very uniform, small and close; similar distribution abactinally.

Internal dissepiments wanting centrally; no septum between the ambulacral and intestinal areas; some needles in the digitations and extending inwards as columns or layers, but scanty in arrangement.

With or without two anterior lunules.

Recent. W. coast of Africa and Cape Verde Islands.

There are two sections of this small genus—(1) with lunules and intermediate ambulacral pores, the type of which is *R. Augusti*, Klein; (2) without lunules, *R. Rumphii*, Klein.

Subfamily *Arachninæ* (p. 158).

Genus ARACHNOIDES, Breynius, 1732, *Sched. de Ech.* p. 64, tab. 7. figs. 7–8. Klein, 1734, *Nat. Disp. Ech.* p. 33, tab. 30. *Agassiz*, 1841, *Monogr. d'Éch. viv. et foss.* livr. 2, *Les Scutelles*, p. 94. *Gray*, 1851, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 13. *A. Agassiz*, 1873, *Revision*, p. 528. *Lovén*, 1874, *Études*, p. 34.

Syn. *Asterodaspis*, Conrad; *Alexandria*, Pfeffer, 1880 (?).

Test thin, very depressed, outline circular, edge thin, slightly subconical dorsally.

Apical system central, tumid, the madreporite surrounded by radial plates and four or five genital pores.

Ambulacra very large, greatly exceeding the interradia in area, the petaloid portion with narrow poriferous zones very widely divergent and open distally; plates of petaloid part compound, an aboral demi-plate and a large adoral primary plate; the transverse sutures riddled with minute pores; actinally the plates form the whole of the peristomial margin or not; the ambulacral grooves straight, perforated by two buccal pores; with or without a process passing over the margin; and reaching the apex, imperforate. Two spheridia to each ambulacral groove near the peristome, hidden.

Interradia small, narrow apically, ending there with two plates, excluded from the peristome or not; not perforated by pores.

Peristome subpentagonal, central.

Jaws flat, with a crest and small rotulæ; teeth superior. The perignathic processes are stout, moderately tall and bent; there are two placed side by side on each peristomial interradial plate.

Periproct abactinal, near the posterior margin, small, circular. Tubercles of the ambulacra in oblique series; interradial tuberculation coarse, irregular, largest and least crowded actinally.

The internal structure of the test shows concentric rows of disconnected calcareous walls or calcareous pillars near the inner edge, branching and stellate nearer the middle of the test; neither partitions limiting the ambulacra near the margin, nor hard structures separating the ambulacral and intestinal areas.

Fossil. Pliocene: California.

Recent. Amboyna, N. Australia, Flinders Is., New Zealand, East Indian Islands, Burmah, Mergui.

Alexandria, Pfeffer, 1880, Verhandl. d. nat. Vereins. v. Hamb.-Altona, n. F. v. p. 63, appears to be an *Arachnoides* with a posterior notch.

VI.

Order V. The Spatangoida. Suborder Cassiduloidea. The Family Echinoneidæ, Subfamilies and Genera. Genera incertæ sedis. Family Cassidulidæ and its Alliances and Genera and Subgenera. Family Collyritidæ and Genera. The Family Plesiospatangidæ and Genera.

Order V. SPATANGOIDA (p. 25).

Suborder CASSIDULOIDEA.
„ SPATANGOIDEA.

I. Suborder Cassiduloidea.

Exocyclic nodostomes with a transverse or an oblique elliptical or irregularly shaped or pentagonal peristome; with or without "floscelles." Apical system either compact or elongate. Ambulacra abactinally simple, petaloid or subpetaloid, usually similar. Interradia, some or all, with a single peristomial plate; the postero-lateral areas symmetrical actinally, without any fusion of plates; no plastrons. Periproct in the posterior interradium.

I. *Family* ECHINONEIDÆ.
Subfamilies *Echinoconinæ, Echinoneinæ, Oligopyginæ, Echinobrissinæ.*
II. *Family* CASSIDULIDÆ.
III. „ COLLYRITIDÆ.
IV. „ PLESIOSPATANGIDÆ.

I. Family ECHINONEIDÆ.

Cassiduloidea with variously-sized tests, ovoid or subpentagonal in marginal outline; tall, subconical, or subhemispherical, or low and tumid dorsally; tumid and rarely flat actinally. Apical system central, compact or subcompact, with four perforated basal plates. Ambulacra similar, moderate in width to narrow, dorsally apetalous or subpetaloid, rarely tending to close. Pores in simple pairs or rarely in oblique triplets actinally; no floscelle. Tentacles homoiopodous. Peristome oblique or transverse and elliptical, rarely symmetrical; the number of interradial peristomial plates variable. Periproct actinal, marginal or supramarginal.

This Family is subdivided into four subfamilies.

I. Subfamily *Echinoconinæ.*

Tall, conical or subhemispherical tests, rather flat actinally; the peristome more or less symmetrical; ambulacra with triplets of pairs of pores actinally; periproct submarginal or marginal.

Genus *Echinoconus.*
Lanieria.

Genus ECHINOCONUS, Breynius, 1732, *Schediasma de Ech.* p. 57, pl. 3. fig. 12. *Desor*, 1842, *Monogr. d'Éch. viv. et foss.* livr. 3, p. 7. *E. Forbes*, 1850, *Mem. Geol. Surv.* decad. iii. pl. viii. *Cotteau & Triger*, 1859, *Éch. de la Sarthe*, p. 279. *Lovén*, 1872, *Études*, pl. xv. *Martin Duncan*, 1884, *Geol. Mag.* p. 10. *Lovén*, 1887, *Bihang till Kongl. Svensk. Vet.-Akad. Handl.* Bd. 13, Afd. iv. no. 10 (Stockholm, 1888), p. 10. *Duncan & Sladen*, 1889, *Ann. & Mag. Nat. Hist.* ser. 6, vol. iv. p. 238.

Syn. *Galerites*, Lmk. 1816, Anim. s. Vert. vol. iii. p. 20; Desor, 1842. *Conulus*, Klein.

Test moderate, thin; oval, circular, or subpolygonal in marginal outline; tall, conical, subconical, or tumid and subhemispherical dorsally, flat or slightly tumid actinally.

Apical system small, compact, with four basal plates which are perforated; the madreporite in the right anterior, the basals 1 and 4 in contact and behind the madreporite, or slightly separated by one or by both of the posterior radial plates; antero-lateral radial plates separating the basal plates or not.

Ambulacra flush, or slightly raised, apetalous, straight; plates both low primaries and demi-plates, with larger primaries, some compound plates; pairs of pores small, in simple series abactinally and in oblique triplets actinally and close to the peristome. Interradia with a moderate number of broad, not very high plates.

Ornamentation of numerous small primary tubercles, and an epistroma of scattered distant sharpish granules.

Peristome central, sunken, slightly decagonal, symmetrical; some interradial marginal regions with one plate only; with an ascending, slightly developed tube; ten small, thick, buccal plates close to the margin. Perignathic girdle reduced to a thickening of the interradia as a low false ridge. Jaws none. Periproct marginal or submarginal.

Fossil. Cretaceous: England, Europe, N. Africa, Asia.

It does not appear that the interesting species first of all noticed by d'Orbigny, and redescribed by M. Cotteau, Desc. Éch. foss. de Cuba, 1881, in Ann. de la Soc. géol. de Belg. vol. ix. Mém. p. 11, pl. i., can enter *Echinoconus*. I have therefore defined a genus *Lanieria* for the so-called *Echinoconus Lanieri*.

Genus LANIERIA, gen. nov.

Test moderate, high, subglobular, slightly elliptical in marginal outline, broader than high, narrower and slightly tumid actinally.

Apical system central, projecting, pentagonal, with five basals largely perforated by genital ducts; madreporite in the right anterior, and also occupying the centre of the system and separating basals 1 and 4 and reaching basal 5. Radial plates entering the periproctal ring.

Ambulacra straight, narrow, flush, apetaloid; pairs of pores directly superimposed except actinally, where there is an arrangement of triplets in arcs. Tubercles of the interporiferous areas small, perforate and crenulate, larger near the poriferous zone, in two or more vertical rows.

Interradia large, with several vertical rows of primary tubercles, two of which reach the apex, scrobiculate and with granules between.

Peristome central, circular, slightly notched. Periproct rather large, elliptical, close to the peristome and reaching close to the posterior edge of the test.

Fossil. Cretaceous or Eocene: America (Cuba).

This genus admits *Galerites*=*Echinoconus Lanieri*, d'Orb.

II. Subfamily *Echinoneinæ*.

Tumid, low tests, more or less pulvinate actinally; peristome central or subcentral and oblique.

Genus *Echinoneus*.
Amblypygus.
Caratomus.
Pygaulus.
Pyrina.
Subgenus *Nucleopygus*.
Genus *Anorthopygus*.

Genus ECHINONEUS, Van Phelsum, 1774, *Brief aan Cornelius Nozeman*. Leske, apud Klein, 1778, p. 173. *Desor*, 1858, *Synopsis*, p. 197. *Lovén*, 1872, *Études*, pls. ix. and xv. *A. Agassiz*, 1872–74, *Revision*, p. 332. *Duncan*, 1884, *Geol. Mag.* p. 17.

Test small, thin, elongate-ovoid in marginal outline, tumid dorsally, flat actinally, depressed.

Apical system central, small, compact; four basal plates perforated by ducts, the posterior pair united, sutures fused, fifth basal absent; the madreporite in the right anterior basal. Radial pores very small.

Ambulacra similar, flush, apetaloid, narrow, broadest above the ambitus; poriferous zones narrow, straight, sunken or not; pairs of pores numerous, in straight series, some are in low primaries and others are in larger primaries associated with a small demi-plate also carrying a pair. Tubercles of the interporiferous areas crowded, sunken or not, small, simple, and without mamelons.

Interradia with crowded tubercles resembling those of the ambulacra; but many small, glassy, spineless tubercles of epistroma occur.

Actinally the ambulacra are unequally broad, in consequence of the obliquity of the triangular, rounded-angled, large, central peristome. This is longest between the interradia 2 and 4 and the edge of ambulacrum v. At the peristomial margin the interradia 2 and 4 have two plates, but all the others only have one. The actinal membrane is covered with pentagonal plates, which become more numerous towards the centre of the area and the small mouth.

Periproct inframarginal, large, long, oval, separated from the peristome by a single interradial peristomial plate and the succeeding pair of plates. The membrane without tentacles. Periproctal plates large near the edge anteriorly. Spines short. Ambulacral tentacles homoiopodous, disciferous.

Fossil. Miocene: N. America. Late Tertiary: Guadeloupe, Cuba.

Recent. Caribbean Sea, Florida, Australia, Kingsmill Islands, Zanzibar.

Genus AMBLYPYGUS, *Agassiz*, 1840, *Catal. Syst. Ectyp. Echin. Mus. Neoc.* p. 7. *Desor*, 1858, *Synopsis*, p. 255. *Duncan & Sladen*, 1883, *Pal. Ind.* ser. xiv., *Foss. Ech. Kachh & Kat.* p. 12. *Duncan*, 1884, *Geol. Mag.* p. 17.

Test large, stout, ovoid or subpentagonal at the tumid ambitus, moderate or depressed in height, tumid and convex dorsally, more or less swollen actinally, around the peristome.

Apical system central or subcentral, small, four basal plates with large ducts, and perforated by the madreporite, which is largely in the right antero-lateral basal, and which may pass between the postero-lateral basals and even separate the posterior radial plates. Radial plates small.

Ambulacra narrow, flush or slightly raised, apetaloid, continuous from the apex to within the peristomial tube; poriferous zones expanding below the apical system and contracting before reaching the ambitus, thence becoming very narrow and consisting of a straight series of oblique small pairs; at the expanded part the pairs are separated by a raised costa, the inner pores are circular, the outer series being transversely elongate and the pores are connected by a groove. Plates are mainly low primaries, each with a pair of pores; but many are composed of a small demi-plate and a large primary combined.

Interradia broad; unequally broad at the peristome, where the plates are single in all the areas except 2 and 4, in which there are two peristomial plates; all these plates pass up slightly and form a kind of mouth-tube.

Tubercles of both areas very small, crenulated, distant, and separated by sharp epistromal granules.

Peristome large, oblique, the long axis between interradia 2 and 4, sunken, deep, widely open, irregularly triangular, with a long and short axis, subcentral. Periproct large, pear-shaped, its long axis in that of the test, situated near the peristome and between it and the posterior margin.

Fossil. Cretaceous: Cuba (?). Eocene: Europe, E. Africa, Asia. Tertiary: Jamaica.

Genus CARATOMUS, *Agassiz*, 1840, *Catal. Syst. Ectyp. Ech. Mus. Neoc.* p. 7. *Desor*, 1842, *in Agass. Monogr. d'Ech. viv. et foss.* livr. 3, p. 35. *Cotteau & Triger*, 1859, *Éch. de la Sarthe*, pl. xxxi. figs. 15–19.

Test small, depressed, ovoid or elliptical in tumid outline,

rather widest posteriorly, swollen dorsally, flat or pulvinate actinally, and may be subrostrated behind.

Apical system compact, with four basal plates well perforated; the madreporite large and extending backwards in the usual basal, separating the posterior lateral basals and touching the posterior radial plates which are in contact.

Ambulacra moderately broad, straight, flush, widest at the ambitus, narrowing dorsally and less so at the peristome; plates primaries, low, broad, each with a pair of pores; pairs of pores in simple straight series dorsally, continued to the peristome.

Interradia with a moderate number of plates with small ornamentation.

Peristome central and oblique, the long diameter being between ambulacrum v. and interradium 2, sunken. Periproct inframarginal and marginal, triangular, with rounded angles.

Fossil. Cretaceous: England, Europe, Africa.

There may be some backward prolongation of the peristome in some species of *Caratomus*, and in M. Cotteau's valuable memoir it appears that its long axis may be between amb. ii. and amb. iv.

The next genus is not a satisfactory one, for some of the species are barely separable from *Caratomus*, and there is some doubt about the generic position of the N.-African forms with semi-petaloid ambulacra.

Genus Pygaulus, *Agassiz*, 1847, *Catal. rais.*, *Ann. d. Sci. Nat.* vol. vii. p. 158. *Desor*, 1858, *Synopsis*, p. 251. *Cott.*, *Peron & Gauth.* 1876 and 1884, *Éch. foss. de l'Algér.* new ed. of fasc. 2, p. 75.

Test small, thick, tumid at the ovoid or elliptical ambitus, low and slightly convex dorsally, pulvinate actinally, subrostrated posteriorly.

Apical system slightly excentric in front.

Ambulacra narrow, increasing in width to the ambitus and then diminishing; poriferous zones narrow; pairs of pores in simple series, and the shape of the pores of a pair may be different, and either circular or elongate transversely.

Peristome elongate, more or less oblique, and sunken, and the pairs of pores are very slightly crowded at the margin. Periproct inframarginal and ovoid-elongate or marginal.

Fossil. Cretaceous: Europe, N. Africa.

Genus PYRINA, *Des Moulins*, 1833, *Études sur les Éch.* p. 26. *Agassiz*, 1840, *Catal. Syst. Ectyp. Ech. Mus. Neocom.* p. 7. *Desor*, 1842, *in Agass. Monogr. d'Éch. viv. et foss.* livr. 3, p. 25. *De Loriol*, 1873, *Éch. Helv. Crét.* p. 201, pl. 14; 1888, *Faune Crét. Portug., Éch.* vol. ii. fasc. 2, p. 78, pl. xvi.

Test small or moderate, ovoid, elongate, broader than high, tumid at the margins and swollen abactinally, may be pulvinate actinally.

Apical system compact, with four basal plates, the two posterior radial plates close together; madreporite large, in the large right anterior basal plate, reaching back but only to the edge of the posterior basals which are in contact; four generative pores and no fifth basal plate, or complementary plates may exist behind a small madreporite.

Ambulacra flush; poriferous zones narrow, widely open at the ambitus, apart yet closing much actinally. Pairs of pores numerous, small, and separated by costæ, non-conjugated, in simple series dorsally, more or less in oblique triplets actinally; plates primaries, low and broad, with demi-plates. Interradia broad.

Peristome nearly or quite central, elongate-elliptical, slightly oblique, the long axis being between zone *b* of amb. iii. and zone *a* of amb. i.

Ornamentation of both areas diffused and very equal, of sunken primary tubercles, crenulate and perforate, with large and small rounded granules on the intermediate structure.

Periproct pyriform, supra-marginal, elongate, but remote from the apical system.

Fossil. Cretaceous: England. Cretaceous and Eocene: Europe. Cretaceous: N. Africa.

Subgenus NUCLEOPYGUS, (genus) *Agassiz*, 1840, *Catal. Syst. Ectyp. Ech. Mus. Neoc.* p. 7. *Desor*, 1842, *in Agass. Monogr. d'Éch. viv. et foss.* livr. 3, p. 32; *Synopsis*, 1858, p. 188 *a*.

Test small, circular or oblong in tumid marginal outline, depressed, swollen above, subpulvinate actinally.

Apical system compact, with four basal plates and five radial plates all perforated, the posterior radials touch.

Ambulacra apetalous, straight; pairs of pores in simple series.

Peristome circular or elliptical, but with a decagonal outline.

Periproct large, superior, more or less remote from the apical system.

Fossil. Oolite and Cretaceous: Europe.

It is an unsatisfactory genus, and probably will merge entirely into *Pyrina*.

De Loriol, 1888, Faune Crét. du Portug., Éch. vol. ii. fasc. 2, p. 80, describes *Pyrina globosa*, which is inseparable from the genus, and obviates the necessity of retaining the genus *Globator*, Agassiz, 1880.

Genus ANORTHOPYGUS, *Cotteau*, 1859, *Éch. de la Sarthe*, livr. 4, p. 177, pl. xxxi. figs. 1–9; 1863, *Éch. Foss. des Pyrén.* p. 36. *De Loriol*, 1888, *Faune Crét. du Portug.*, *Éch.* vol. ii. fasc. 2, pl. xiii.

Test of moderate size, more or less swollen above, low; almost flat below; subpentagonal or circular in outline at the ambitus; sometimes subconical and moderately high, and slightly truncated behind.

Apical system central, compact, granular at the surface, with four basal plates and five radial plates. Madreporite large, in the right anterior basal, and separating the postero-lateral basals 1 and 4, occupying the position also of the posterior basal, and separating the posterior radial plates.

Ambulacra narrow, increasing in width to the ambitus, and then narrowing to the peristome. Poriferous zones simple, converging above, and pairs simply superposed.

Peristome elliptical, longest transversely in an opening in a deep impression on the actinal surface; branchial incisions small. No traces of jaws or a perignathic girdle. Periproct flush with the test, large, oblique, irregular, situated between the apex and the posterior margin. Tubercles of the areas small, perforated, crenulate and scrobiculate.

Fossil. Cretaceous (Cenomanian): Europe.

III. Subfamily *Oligopyginæ*.

Tests with very small periproctal openings.

Genus *Haimea*.
Oligopygus.

The next genus is a very unsatisfactory one.

Genus HAIMEA, *Michelin*, 1851, *Rev. et Mag. de Zool.* p. 92.

Test small, moderately high, tumid and slightly elongate. Apical system nearly central and with four generative pores.

Ambulacra tumid, imperfectly petaloid, open, passing over the margin to the peristome; pores oblique.

Peristome central, pentagonal, and without bourrelets. Periproct very small, oval, and placed nearer the peristome than the posterior margin.

There is only one species to this genus, and the geological position is not known. In Michelin's figure the form is not larger than a nut, it is truncated posteriorly, and swollen and subspherical; it appears to be a figure of a cast.

Fossil. Distribution unknown. (Cretaceous ?, France.)

Genus OLIGOPYGUS, *De Loriol*, 1887, *Rec. Zool. Suisse*, t. iv. no. 3, p. 394.

Test moderately large, thick, oval, elongate, depressed, tumid actinally.

Apical system central or subcentral, compact, small, four perforated basals; madreporite central and extending to the posterior radials; radial plates with very small pores.

Ambulacra slightly differing in length, otherwise similar, almost flush, semi-petaloid, widely open. Poriferous zones broad; pores equal.

Peristome central, elliptical, broader than long, in a concavity of the test; floscelle and jaws wanting. Periproct very small, circular, opening actinally between the peristome and posterior margin. Tubercles small, imperforate, scrobicules sunken.

Fossil. Tertiary: Florida, N. America.

IV. Subfamily *Echinobrissinæ.*

Tests depressed, elongate, tumid. Ambulacra subpetaloid. Apical system and peristome excentric, the latter variable in shape, and with single interradial marginal plates; floscelle absent or rudimentary. Periproct supramarginal.

Genus *Echinobrissus.*
  Subgenus *Dochmostoma.*
  Oligopodia.
Genus *Anochanus.*
  Botriopygus.
  Ilariona.

Few genera of the Echinoidea have received more attention than *Echinobrissus*, Breynius, and *Nucleolites*, Lamarck. They have been most satisfactorily and candidly studied by Cotteau and A. Agassiz during late years, and have been united by the last-named author. He has shown that the singularly insufficient character which was supposed to separate the genera, namely, the presence or absence of grooving between the pores of a pair, may be seen in the same petal of a specimen of a species.

The so-called conjugation of pores of a pair is of no physiological importance, and taken alone is of no classificatory value; but when it occurs with other characters it may assist to group sets of species together in a genus. The obliquity of the peristome is of greater importance, and, all other characters being the same, it is of subgeneric value; but if other characters of importance differ, the obliquity should be of generic value. But in *Echinobrissus* the obliquity is of subgeneric value, and relates to the forms which d'Orbigny, not very felicitously, called *Trematopygus*.

The possibility of retaining the recent species in the genus is a matter of doubt, and as they have modifications of the poriferous zones below the petaloid portions, they should come under a subgenus *Oligopodia*.

Genus Echinobrissus, Breynius, 1732, *Schediasma de Echin.* p. 62. *Gray*, 1825, *Ann. Phil.* p 7; 1855, *Cat. Ech. Brit. Mus.* p. 37. *Milne-Edwards*, 1836, *Cuvier's Règ. Anim.* ed. iii. *Desor*, 1858, *Synopsis*, pp. 257, 263. *Zittel*, 1864, *Novara Reise, Foss. Molusc. u. Ech. a. N. Zealand*, p. 62. *A. Agassiz*, 1872–74, *Revision of the Echini*, pp. 555 & 557. *Cotteau*, 1884, *Bull. Soc. Zool. France*, vol. ix. p. 336. *Duncan*, 1887, *Quart. Journ. Geol. Soc.* xliii. pp. 420 & 429. *Bell*, 1887, *Ann. & Mag. Nat. Hist.* ser. 5, vol. xx. p. 125.

Syn. *Nucleolites*, Lamarck, 1801; Agassiz, 1847, Cat. rais., Ann. des Sci. Nat. vii. p. 153. *Trematopygus*, d'Orbigny.

Test rather thin, depressed, elongate, rounded in front, broadest and more or less truncated behind; or square, with the angles rounded; or subcircular; tumid above, concave actinally. Abactinally grooved posteriorly.

Apical system subcentral or excentric in front; four perforated basal plates; madreporite in right anterior basal, or extending into others, or separating the lateral basals of one side from

those of the other; usually the postero-lateral radial plates are in contact; or complementary plates may separate the postero-lateral basals and radials.

Ambulacra unequal, flush or slightly raised, open at the end of the subpetaloid parts; pairs of pores in simple series, more or less unequal in shape and size, the outer elongate; below the subpetaloid part the pores in small oblique pairs, conjugate or not.

Peristome excentric in front, deeply seated, pentagonal, elongate or rarely circular, elliptical, transverse or oblique; without bourrelets, and with very rudimentary or absent phyllodes, and only slight doubling of pores. Periproct usually elongate longitudinally, may be transverse, placed at the upper part of the posterior groove, which extends with variable lengths towards the apex; periproctal membrane with large plates near the edge. Tuberculation small, larger actinally.

Fossil. Oolite: England, Europe, Asia. Cretaceous: England, Europe, N. Africa, Asia. Eocene: Europe. Tertiary (late): Australia, N. Zealand, Java.

Subgenus DOCHMOSTOMA.

Syn. *Trematopygus*, (genus) d'Orb.

Peristome oblique.

Fossil. Cretaceous: Europe, N. America.

Subgenus OLIGOPODIA.

Ambulacral pores single below the petaloid part.

Recent. New Zealand, Madagascar, East Indian Islands.

Cotteau has probably seen and examined more species of *Echinobrissus* than any other palæontologist, and as far back as 1871 he gave an amended diagnosis of the genus in Pal. Franç., Terr. Jura, ix. p. 233. He noticed the variability of the position of the madreporite and of the periproct. Later, in 1884, the same careful observer (Bull. Soc. Zool. de France, p. 336) stated that, after a study of twenty-six species, he found that the madreporite in general touches the postero-lateral basal plates, and that sometimes it separates these plates, and it may even separate the postero-lateral radial plates; even complementary plates may separate the basal plates and the radials, these structures not being seen in all individuals of the same species. The periproct varies in its position from touching the apical system to

anywhere between the apical system and the posterior margin of the test.

These remarks dispose of the five genera or subgenera suggested by M. Pomel; M. Cotteau (*op. cit.* p. 336) writes that the characters depended upon for their separation are of specific value only.

We shall have to recur to this decision, in which we fully concur, further on in noticing the forms referred to *Hemiaster.*

It is certain that the typical species of *Echinobrissus*, as well as the recent forms, have no true floscelle, and this condition is exemplified in *E. Meslei*, Peron & Gauthier, from Algiers. But MM. Cotteau, Peron & Gauthier, and also M. Coquand, admit species into the genus which have bourrelets and phyllodes, such as *E. Julieni*, *E. inæquiflos*, *E. sitifensis*, and others which are described in 'Éch. foss. de l'Algérie,' fasc. 7 & 8. These have well-developed phyllodes and all the characters of *Cassidulus*, except the unimportant actinal median bare band (see *Cassidulus*).

Genus Anochanus, *Grube*, 1869, *Monatsb. d. k. preuss. Akad. d. Wiss. zu Berlin* (1868), p. 178.

Test small, resembling *Nucleolites epigonus*, Martens *, in shape, and in the position of the peristome and periproct; having no visible madreporite or basal plates; the dorsum occupied by a marsupium which does not lead into the cavity within the test, but which is surrounded by a raised rim of calcareous tissue, lined with soft parts which bend in from the outer derm, and are covered with pedicellariæ and protected at the narrow external opening by spines; larger pedicellariæ on the outside of the test. The perfect young are found within the marsupium with spines on them.

Recent. Probably China.

Genus Botriopygus, *d'Orbigny*, 1855, *Pal. Franç., Éch. terr. Crét.* p. 334. *Desor*, 1858, *Synopsis*, p. 278, pl. xxxi. *De Loriol*, 1873, *Pal. Suisse, Terr. Crét.* pl. xvi. fig. 3; 1884, *Rec. Zool. Suisse*, i. p. 615.

Test small and moderate, elongate ovoid at the narrow, tumid, somewhat undulating margin, broader behind than anteriorly,

* *Oligopodia epigonus*, Martens, sp.

and more or less truncated, low and arched dorsally, flat or concave actinally; grooved or not posteriorly.

Apical system excentric in front, small, and with four perforated basal plates.

Ambulacra flush, unequal, long, open, and subpetaloid, the pores unequal; zones broad.

Peristome sunken, excentric in front, oblique, subpentagonal, with only slight doubling of pairs of pores, and no true floscelle. Periproct supramarginal, oval, elongate. Tubercles nearly equal in size throughout.

Fossil. Cretaceous: Europe, Asia (S. Hindustan), N. Africa.

Genus ILARIONA, *Dames*, 1877, *Palæontographica*, n. F. i. (xxv.) p. 34.

Test elongately oval or oviform, subdepressed, more or less convex above, flat or slightly convex below; margins very thick or tumid.

Apical system compact, excentric in front.

Ambulacra petaloid; petals short, unequal, lancet-shaped, contracting and nearly closed. Poriferous zones equal; pores round or oval, conjugate.

Peristome decagonal or subdecagonal, with a raised rim and special tubercles. Floscelle absent. Periproct elongately oval, on the upper part of the posterior vertical truncation of the test.

Ornamentation very uniform; tubercles small, sunken in deep scrobicules, close; miliary granulation confluent and compact. A more or less bare band between the peristome and periproct.

Fossil. Eocene: Europe, Asia (Sind).

The peculiar and distinctive structure of the peristome was discovered and carefully pointed out by W. Dames. He notices (Ech. d. Vicent. u. Veron. Tertiär. p. 34, Palæontographica *ut suprà*) the outline is decagonal, which might be represented by an equilateral pentagon from which the angles had been abruptly truncated by short lines—the long lines, corresponding with the interradia, being granular, whilst the short lines, corresponding with the ambulacra, are smooth. At the junction of the long and short lines a small smooth tubercle is present, the peristome being therefore surrounded by ten of these protuberances. The margin of the aperture is raised, and extends far into the body-cavity.

Genera incertæ sedis.

Genus *Desorella.*
Oviclypeus.

Genus Desorella, *Cotteau*, 1862, *Rev. et Mag. de Zool.* (pars); *and* 1867–74, *Pal. Franç., Ech. terr. Jura*, ix. p. 384.

Test of moderate size, subcircular in undulating ambital outline, subconical dorsally, pulvinate actinally.

Apical system absent, leaving a large scar; probably a large madreporite separated the posterior radial plates.

Ambulacra with simple pairs of pores, not doubling near the peristome.

Peristome subdecagonal, oblique or not, sunken. Periproct elongate, just supramarginal, large, pyriform, distant from the apical system.

Fossil. Oolite: Europe.

This is now a very unsatisfactory genus, and it formerly included *Pseudodesorella*, which is a well-defined genus. It has been determined from casts of species.

Genus Oviclypeus, *Dames*, 1877, *Palæontographica, Cassel*, Bd. xxv., *Ech. Vicent. u. Veron. Tert.* p. 44.

Test large, with an oval tumid margin, subhemispherical dorsally, slightly tumid actinally.

Apical system slightly excentric in front, small, with four genital pores.

Ambulacra similar, with wide poriferous zones extending to the ambitus and furthest apart there, diverging regularly from the apex downwards, diminishing in the distance of their pores at the margin of the test, showing no tendency to close. Pores circular, becoming slit-shaped with distance from the apex, wide apart and probably with a wide intermediate groove, lasting to the narrowest part of the zone; costæ with close miliaries. Interporiferous areas narrow, with numerous small, close primary tubercles, which are probably plain and scrobiculate. Actinally ten grooves extend from the margin to the peristome, producing the appearance of five compound grooves, each groove is a poriferous zone; no doubling of the pairs is seen.

Interradia tumid, wider than the ambulacra, crowded with similar small, scrobiculate, primary tubercles, some hexagonal.

Peristome slightly excentric in front, deeply sunken, the interradial margins projecting and tumid. Periproct marginal, moderately large, elliptical, with a downward projection.

Fossil. Eocene: Europe.

II. Family CASSIDULIDÆ.

Cassiduloidea with very variably shaped tests; ambulacra petaloid, subpetaloid, or apetalous dorsally, and with crowded doubling of the pairs of pores close to the peristomial margin, forming with the single swollen and ornamented interradial peristomial plates "a floscelle."

This Family contains 27 types, and they may be grouped artificially around four genera.

Alliance of Genus *Cassidulus*.
Subgenus *Rhynchopygus*.
Pygorhynchus.
Genus *Stigmatopygus*.
Echinanthus.
Subgenus *Hardouinia*.
Genus *Eurhodia*.
Paralampas.
Alliance of Genus *Catopygus*.
Subgenus *Studeria*, subgen. nov.
Genus *Neocatopygus*.
Phyllobrissus.
Alliance of Genus *Clypeus*.
Subgenus *Clypeopygus*.
Genus *Pygurus*.
Faujasia.
Galeroclypeus.
Pseudodesorella.
Alliance of Genus *Echinolampas*.
Subgenus *Milletia*.
Genus *Phylloclypeus*.
Conolampas.
Plesiolampas.
Subgenus *Oriolampas*.
Genus *Palæolampas*.
Microlampas.
Neolampas.

A. Agassiz gives some very valuable notes upon the distinction of the genus *Cassidulus*, Lmk., and the genus *Rhynchopygus*,

d'Orb. He observes (Revision, p. 342) that Lamarck's genus contained two types, *C. lapis-cancri* and *C. caribbearum*, with *C. Marmini*, the former being retained to represent the typical Cassidulids, and the others being associated with the genus *Rhynchopygus* by Desor and Lütken. He places, however, this last-mentioned genus as a subgenus. I consider that this is the correct view, and therefore the most beautiful and elaborate drawings of *C. caribbearum* and other forms given by Lovén, in his Études, figs. 61–67 & 130, 179, relate to the subgenus. Desor relied too much upon the taxonomic value of one of the structures of *Cassidulus*, viz. the cribriform or smooth tubercle-less median actinal band, which has been shown by Lovén to be unimportant, as it may be seen in the subgenus as well as in the type; or it may not exist (see also A. Agassiz, Revision, pl. xv. fig. 3). The only distinction is the lateral extension of the overhanging periproct of *Rhynchopygus*.

Genus Cassidulus, *Lamarck*, 1801, *Syst. Anim. sans Vert.* p. 348. *Agassiz & Desor*, 1847, *Cat. rais.*, *Ann. Sci. Nat.* vii. p. 157. *Desor*, 1858, *Synopsis*, p. 288. *Lütken*, 1863 (pub. 1864), *Vid. Medd. f. Naturh. Foren. i Kjöbenh.* p. 126. *A. Agassiz*, 1872–74, *Revision*, p. 342.

Syn. *Trochalia*, Pomel, 1883 = *Asterobrissus*, De Loriol, 1888.

Test small, oblong, depressed, broadest posteriorly, longer than broad, broader than high, convex abactinally, flat actinally.

Apical system excentric in front or subcentral; four perforated basal plates; the madreporite passing back and separating the postero-lateral basals, but not the radial plates.

Ambulacra subsimilar, short, flush, subpetaloid, not closing; pores continued from the petaloid part to the floscelle, which is well developed. Tentacles both simple and branchial (heteropodous).

Peristome excentric in front, the bourrelets narrow and strong, the phyllodes in grooves. One peristomial plate to each interradium. Usually a median band behind the peristome where there are no tubercles, and where the test is either cribriform, pitted, or plain, or it may be absent. The periproct supramarginal, at the commencement of a groove, elongate longitudinally. Tubercles small and very close abactinally, large and distant actinally, except on the median area posteriorly.

Fossil. Cretaceous: Europe, Asia, N. Africa, W. Africa, and N. America. Eocene: Europe, Asia, N. America.

Subgenus RHYNCHOPYGUS, *d'Orbigny*, 1855 (genus), *Pal. Franç., Terr. Crét.* vi. p. 324. *A. Agassiz*, 1872–4, *Revision*, pp. 342, 553.

Cassidulids having a test with a rostrum overhanging a transversely elongate supramarginal periproct.

Fossil. Cretaceous: Europe. Eocene: Europe, Africa, Asia. Late Tertiary: Guadeloupe, W. Indies.

Recent. Caribbean Sea, Panama, California, Galapagos.

Subgenus PYGORHYNCHUS, *Agassiz*, 1839, *Échin. foss. Suisse*, p. 53.

Syn. *Cyrtoma*, M'Clelland, 1840.

Test moderate in size, tumid abactinally, concave actinally. Petals long.

Peristome longest transversely, with a well-developed floscelle. Periproct supramarginal and transverse. A more or less bare median band in the posterior interradium actinally.

Fossil. Cretaceous: Europe, Asia. Eocene: Europe. Miocene: Europe, America, Australia.

Genus STIGMATOPYGUS, *d'Orbigny*, 1855, *Pal. Franc., Terr. Crét.* vi. p. 331. *Desor*, 1858, *Synopsis*, p. 296. *Stoliczka*, 1873, *Cret. Fauna S. India, Mem. Geol. Surv. Ind., Pal. Ind.* ser. viii. vol. iv. pt. 3, p. 27.

Test of moderate size, ovate in marginal outline, subhemispherical, flat actinally.

Apical system subcentral, with four basal plates, the madreporite in the largest, the right anterior; the basal plates perforated by genital ducts except the right anterior.

Ambulacra petaloid, narrow, moderate in length, none reaching the margin, unequal, narrowed distally, the anterior the longest.

Interradia finely granular actinally, with coarse mamillated tubercles most numerous at the floscelle, large and finely tuberculated abactinally.

Peristome slightly depressed, large, subpentagonal; floscelle greatly developed, the bourrelets long and tumid, and projecting into the peristome, and the ambulacral lips angular, large, and projecting inwards, the phyllode being on either side of them.

The periproct is narrow bottle-shaped at the upper part, in a long, narrow, posterior groove, which is shallowest and broadest just above a tongue-shaped slope at the margin of the test; irregular minute grooves on the sides of the groove. Spines small, closely, longitudinally striated.

Fossil. Cretaceous: Europe, Asia (S. Hindustan), W. Africa.

Genus ECHINANTHUS, Breynius, 1732, *Sched. de Echinis*, p. 53 (pars). *Desor, Synopsis*, 1858, p. 291. (See p. 149 of this Revision.)

Syn. *Parapygus*, Pomel, 1883.

Test moderate and small, thin, ovoid and broadest posteriorly at the tumid undulating margin, low, convex above, concave actinally.

Apical system with four perforated basal plates; madreporite small, slightly excentric in front, but separating the postero-lateral basals and also the radials.

Ambulacra unequal, petaloid, varying in the amount of closure, usually short, but may be long, continued simply over the margin, and developing into phyllodes at the peristome; the poriferous zones may be unequal. Interradia well developed.

Peristome excentric in front, less so than the apical system; a pentagonal floscelle well developed, and the bourrelets especially. Periproct oval, marginal or supramarginal, placed at the top of a more or less developed groove. Ornamentation of very small tubercles and granules, close, largest actinally.

Fossil. Cretaceous: Europe. Eocene: Europe, Asia, Africa (Egypt).

Echinanthus Mortonis, Mich. sp., is the *Hardouinia Mortoni* of Haime; I agree with Desor (Synopsis, p. 295) in not recognizing Haime's genus; but I consider it is a good subgenus.

Subgenus HARDOUINIA, *J. Haime*, 1853, *d'Archiac & Haime, Anim. foss. de l'Inde*, p. 214.

Test conical, as broad as long. Petals broad, pointed, reaching rather more than halfway to the margin.

Peristome nearly central, with a very well-developed floscelle. Periproct large, midway between the margin and the summit, in a groove.

Fossil. Eocene: Europe. Tertiary: Mississippi, U.S. America.

Genus EURHODIA, *d'Archiac & Haime*, 1853, *Anim. foss. de l'Inde*, p. 214; *Duncan & Sladen*, 1881, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 69.

The test is large, stout, elongate, oval, truncated posteriorly, broad in front, depressed, slightly rounded abactinally, slightly concave actinally, and tumid at the ambitus.

Apical system small, excentric in front; four perforated basal plates; madreporite central.

Ambulacra forming a small abactinal rosette, they are small, unequal, the anterior not petaloid, and more open than the others; pores of pairs unequal.

Peristome large, excentric in front, elongate longitudinally, pentagonal; floscelle highly developed, especially the bourrelets, a pitted median actinal surface. Periproct elongated transversely, supramarginal, in a shallow basal groove, which becomes shallow posteriorly, and is surmounted by a rounded roof.

Fossil. Eocene: Asia (W. Sind).

Genus PARALAMPAS, *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 72.

Test small, high, even hemispherical, longer than broad, tumid above, especially posteriorly, the margin tumid, suboval, and may be overhung by the wider test above; the posterior part of the test precipitous and with a rostrum high up and overhanging the periproct; actinal surface concave.

Apical system slightly excentric in front; four perforated basal plates; the madreporite in the right anterior and passing centrally, and separating the basals on either side.

Ambulacra petaloid, short, subequal, or the anterior the larger and longest and well developed; poriferous zones with oblique and circular pores. Interradia very narrow at the apical system.

Peristome pentagonal, more or less excentric in front, slightly wider than long; floscelle well developed, with wall-like bourrelets. Periproct suboval, elliptical, broad, placed high, supramarginal, with a defined groove below it.

Tubercles small, uniform, crowded, equidistant, sunken in scrobicules, most widely spaced actinally.

Fossil. Eocene: Asia (W. Sind).

Genus CATOPYGUS, *Agassiz*, 1836, *Prodr. d'une Monogr. des Radiaires*, p. 185; 1847, *Cat. Rais.*, *Ann. Sci. Nat.* vol. vii. p. 157. *Cotteau & Triger*, 1839, *Ech. de la Sarthe*, p. 184. *Desor*, 1858, *Synopsis*, p. 282. *Laube*, 1869, *Sitzungsb. Akad. Wiss. Wien*, vol. lix. Bd. 1, p. 190. *Studer*, 1880, *Monatsb. d. k. preuss. Akad. zu Berlin*, p. 861. *A. Agassiz*, 1881, '*Challenger*' *Report*, p. 123. *Duncan*, 1887, *Quart. Journ. Geol. Soc.* vol. xliii. p. 420.

Syn. *Oolopygus*, d'Orb.

Small and moderate-sized Urchins, often cylindroid, longer than broad, rather low, tumid in front, rather keeled on the hinder part of the abactinal surface, truncated vertically posteriorly, where the periproct is high up, usually at the end of a groove and below the end of the keel. Actinally the test is rather swollen. Peristome excentric in front, pentagonal, elongate longitudinally, with phyllodes and bourrelets.

Apical system excentric in front; four perforated basal plates, the fifth absent; madreporite large, separating the posterior basal plates; radial plates small.

Ambulacra narrow, subpetaloid, nearly flush, continuous, with a pair of round pores in each plate as far as the peristome. Pores unequal; the outer of a pair more or less elongate. Granulation very close.

Fossil. Cretaceous: England, Europe, Asia.

I consider that certain Tertiary forms as well as some recent species which have been associated with this well-marked genus should come within the subgenus *Studeria*.

A. Agassiz described and figured *Catopygus recens*, which was dredged by the 'Challenger' (Report on the 'Challenger' Echini, 1881, p. 123); and Studer described *C. Loveni* from the seas to the south of the Cape of Good Hope, in the description of the 'Gazelle' Echinoidea, 1880. Both depart from the Cretaceous type; and A. Agassiz notices the uniporous condition of the ambulacra below the petaloid part, as well as the elongate nature of the outer pores of the pairs within it.

Subgenus STUDERIA.

The test is the same as that of *Catopygus* in shape, peristome, and periproct; but the ambulacra have only one pore in each plate in a poriferous zone below the subpetaloid portions.

Fossil. Australian Tertiaries (*Studeria* (*Catopygus*) *elegans*, Laube, sp.).

Recent. Australian seas, south of Cape of Good Hope, East Indian Archipelago*.

The Eocene representative of the Cretaceous *Catopygi* found in W. Sind is a very striking form, leading from the Cretaceous type to the recent forms classified under *Studeria.* The shape of the test, the small dorsal ambulacral rosette, the single series of extrapetalous pores, the character of the floscelle, and the low position of the periproct distinguish the species, and require the definition of a new and closely allied genus.

Genus NEOCATOPYGUS, *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 76.

Test of moderate size, tumid and high, subrotund marginally, greatest height excentric posteriorly. Abactinal area convex; sides tumid, high; actinal surface convex, posterior extremity subrostrate and prominent.

Apical system excentric slightly in front, small, compact; four basals, all perforated for the genital ducts; madreporite large in the right anterior basal, and extending so as to separate the other basals.

Ambulacra petaloid; petals short and subequal, open at the extremity; pores unequal; extrapetalous pores single. Floscelle well developed; phyllodes with an inner series of supplemental pores.

Peristome small, pentagonal, excentric in front, bourrelets forming an ornamented wall-like rim. Periproct small, subcircular or oval, low, supramarginal, placed at the extremity of the posterior rostration. Subanal area tumid and rostrated, faintly grooved.

Tubercles small, perforate and crenulate, sunken in deep scrobicules. Actinal ornamentation the coarsest.

Fossil. Eocene: Asia (W. Sind).

* The genus *Oolopygus*, d'Orbigny, 1856, only differs from *Catopygus* in the unimportant matter of the pores of the pairs not having a groove between them. This defect has no physiological bearing; and indeed it is doubtful whether all the pairs of every specimen of a species of *Catopygus* are united by a groove. *Oolopygus* of the Upper Chalk is a synonym of *Catopygus.*

Genus PHYLLOBRISSUS, Cotteau, 1857–58, *Éch. foss. de l'Yonne*, vol. ii. p. 81. *De Loriol*, 1861, *Anim. invert. de Mont Salève*, p. 165; 1873, *Éch. Helv.*, *Terr. Crét.* p. 233, pls. xviii., xix. *Cotteau, Peron & Gauthier*, 1879, *Éch. Foss. de l'Algérie*, fasc. 5, p. 157.

Syn. *Anthobrissus*, Pomel.

Test of moderate size, oblong, subcircular and rounded rather high in front, subtruncated posteriorly, swollen above, and almost flat actinally. Summit subcentral.

Apical system compact, with four perforated basal plates and five perforated radial plates.

Ambulacra petaloid, with narrow poriferous zones; inner pores round; outer pores elongate; zones more or less open.

Peristome slightly excentric in front, flush, pentagonal or may be oblique, with phyllodes and bourrelets. Periproct on the posterior surface at the top of a groove, variable in height, with keeled edges; it becomes narrower, and diminishes at the posterior edge. Tubercles small, scrobiculate, homogeneous, large around the peristome.

Fossil. Lower Cretaceous: England, Europe, N. Africa. Jurassic: Europe.

Genus CLYPEUS, Klein, 1734, *Nat. Disp. Echin.* *Agassiz & Desor*, 1847, *Cat. Rais., Ann. d. Sci. Nat.* vol. vii. p. 156. *Desor*, 1858, *Synopsis*, p. 275. *Wright*, 1859, *Pal. Soc. Monogr., Brit. Foss. Ech. Ool. Form.* p. 360.

Test rather thick, large, circular or somewhat pentagonal in wavy marginal contour, more or less truncated behind, low, discoidal, or slightly tumid dorsally, nearly flat actinally.

Apical system small, excentric posteriorly, or rarely central, with four triangular perforated basal plates, and a large madreporite which occupies the centre of the system, separating the postero-lateral basals and touching the posterior pair of radial plates, which are separated by long, narrow, interradial plates.

Ambulacra wide, petaloid, not closing abactinally, narrow at the ambitus and actinally. Poriferous zones widening rapidly dorsally, and becoming equal in width (or more) to the very equally wide interporiferous areas, then diminishing in width and becoming very narrow, until midway between the ambitus and the peristome, where the pairs are arranged in very oblique triplets forming a

rudimentary phyllode. Pairs of pores in the petaloid parts, with the inner pore small and circular, the outer elongate transversely and in a decided long groove; pairs close, in simple low broad plates, and the costæ granular.

Interradia with broad, bent, low plates, much higher than any of the ambulacral plates, with a very delicate small tuberculation, largest actinally; tubercles scrobiculate, with a low broad boss and small simple mamelon; intermediate granulation rough.

Peristome subcentral or excentric in front, pentagonal, with narrow tumid granular or minutely tuberculated bourrelets and narrow phyllodes in grooves. Periproct in a groove along the median line of the posterior interradium, supramarginal, high up; the length of the groove variable, or the opening may be almost flush with the rest of the test.

Fossil. Oolite: England, Europe.

Subgenus CLYPEOPYGUS, *d'Orbigny* (genus), 1856, *Pal. Franç., Echin. Terr. Crét.* vol. vi. p. 418. *Desor*, 1858, *Synopsis*, p. 273 (genus).

Clypei with the apical system excentric in front, and narrow poriferous zones.

Fossil. Oolite: England, Europe. Cretaceous: Europe.

Genus PYGURUS, *Agassiz*, 1839, *Éch. Foss. de la Suisse*, p. 68; 1847, *Cat. Rais. des Éch., Ann. d. Sci. Nat.* vol. vii. p. 161. *Cotteau & Triger*, 1859, *Éch. de la Sarthe*, p. 65, pl. xiii. *Desor*, 1858, *Synopsis*, p. 309. *De Loriol*, 1888, *Mém. Soc. d. Phys. et Hist. Nat. Genève*, vol. xxx. no. 2, p. 102.

Test large, discoid, angular or undulating in marginal contour or not, and may be emarginate; depressed, subconical, or rather tall and conical dorsally, enlarged and rostrated behind; ambulacra grooved actinally, and the surface otherwise flat or tumid there.

Apical system central or excentric in front, small, with four or five basal plates, disunited, four with ducts; madreporite extending from the right anterior to the centre of the system; radial plates five, small, between the basals, and reaching the madreporite.

Ambulacra flush dorsally, unequal, long, the lanceolate, open petaloid parts reaching far to the ambitus, and tend to, but do not close, continued as narrow lines of pairs of small pores over

the margin and then placed in the deep smooth grooves, expanding and doubling into large and highly-ornamented phyllodes at the peristome.

Peristome excentric in front, pentagonal, with a highly-developed floscelle. Periproct inframarginal, in a special area, close to the posterior edge of the test, pyriform or ovoid and longitudinal, transverse rarely. Ornamentation small, largest actinally, except in the grooves.

Interradia greatly reduced near the apical system, usually with an undulating surface.

Fossil. Oolite: England, Europe. Cretaceous: Europe, N. Africa, W. Africa, N. America?

Genus FAUJASIA, *d'Orbigny*, 1855, *Pal. Franç., Échin. Terr. Crét.* vol. vi. p. 314. *Desor*, 1858, *Synopsis*, p. 316.

Test of moderate size, circular or oval in marginal outline, very convex or conical abactinally; summit slightly excentric in front, rounded or acuminate; subrostrated posteriorly.

Apical system upon the summit, with four perforated basals.

Ambulacra equal, similar, flush, petaloid, but open distally, very short; petals barely reaching halfway to the margin; inner pores circular, outer elongate. Actinal surface flat.

Peristome flush, subcentral, pentagonal, with a distinct floscelle. Periproct small, transverse, inframarginal. Ornamentation very small, largest actinally.

Fossil. Cretaceous: Europe and N. America.

Genus GALEROCLYPEUS, *Cotteau*, 1873, *Pal. Franç., Terr. Jura*, vol. ix. p. 360.

Test variable in size, subcircular in marginal outline, tumid and subconical dorsally, subrostated posteriorly, and strongly pulvinate actinally.

Apical system at the summit, subcentral or slightly posterior, compact, the large madreporite irregularly produced centrally.

Ambulacra similar, narrow, widest at the ambitus, inner pores round, the outer slightly elongate as far as the ambitus, and then equal, round, oblique, and separated by a nodule. Tubercles small, wide apart, perforate, crenulate, and scrobiculate.

Peristome subpentagonal, sometimes oblique, slightly excentric in front, in a deep depression; interradial margins produced and

the ambulacral edges sunken, with a rudimentary floscelle. Periproct on the upper surface, in a groove commencing far from the apical system,

Fossil. Oolite: Europe.

Genus PSEUDODESORELLA, *Étallon*, 1858–9, *Etud. Pal. Haut. Jura*, pt. 2, p. 15. *Desor & De Loriol*, 1868–72, *Éch. Helvet.* p. 303.

Test moderate, oval, broader than long, depressed.

Apical system small, subcentral, slightly posterior, compact, with four perforated basal plates and five perforated radial plates; the madreporite extending backwards and touching the united posterior radial plates.

Ambulacra slightly petaloid, open, the poriferous zone narrow, with the pairs above the tumid ambitus having an inner round and an outer and somewhat elongate series, flush, continued as round pores in pairs to the peristome. Tubercles numerous, distant, perforated and with scrobicules.

Peristome nearly central, pentagonal, rather elongate, with a moderate or absent floscelle. Periproct high up in a small short groove, which touches the posterior radial plates, and enlarges posteriorly.

Fossil. Oolite: England, Europe.

In the species of the genus *Echinolampas*, Gray, 1825, there is great variability of shape, size, and arrangement of the unequal poriferous zones; but I cannot see the propriety of receiving species into the genus which have equal poriferous zones. The genus is a very large and natural one if it is properly restricted.

Genus ECHINOLAMPAS, *Gray*, 1825, *Ann. Phil.* p. 7; 1855, *Cat. Ech. Brit. Mus.* pt. i. p. 34. *Desor*, 1858, *Synopsis*, p. 300. *A. Agassiz*, 1872–4, *Revision*, pp. 335, 551.

Test variable in size, more or less ovoid or circular at the tumid marginal outline; very variable in shape; moderate in height, tumid and vaulted above, very tall and conical or hemispherical, depressed and more or less discoid.

Apical system excentric in front, rarely subcentral, small, with four perforated basal plates; the madreporite large, in the right anterior basal, and extending into the centre of the system, and

separating the postero-lateral basal plates; the radial plates small, the posterior pair separated by the madreporite.

Ambulacra narrow or broad, petaloid to varying distances from the margin; the pores of a pair differing in shape, conjugate, the pairs separated by ornamented costæ; some poriferous zones unequal in length to their fellows, tending more or less to close or not. Beyond the petaloid parts the pores are in single series and small, until the peristome is reached, where they develop a feeble phyllode. Interambulacra large, with higher and fewer plates than the ambulacra.

Peristome slightly excentric in front, or subcentral, or central, pentagonal, with feeble bourrelets and phyllodes. Periproct elliptical, transverse, inframarginal, close to the posterior edge of the test. Tubercles of both areas very equal, small, very uniform, in sunken scrobicules, with miliaries. Spines small, short, forming tufts near the peristome.

Fossil. Eocene: Europe, Asia, Africa, W. Indies. Oligocene: Asia. Miocene: Asia, Australia, Europe, W. Indies.

Recent. Red Sea, Moluccas, East-Indian Islands, Australia, Cape of Good Hope, Senegal, Caribbean Sea.

Subgenus MILLETIA.

Peristome pentagonal, elongate longitudinally, barely sunken. Periproct irregularly circular in outline, close to the posterior edge, and somewhat oblique yet inframarginal.

Ambulacra broad, unequal, very open; poriferous zones nearly equal.

The type is *Echinolampas* (*Milletia*) *elegantulus*, Millet, 1854, Pal. de Maine-et-Loire, p. 178, redescribed by Cotteau, 1883, Bull. Soc. Zool. de France, vol. viii. p. 458, pl. xv. figs. 6–8.

Fossil. Europe?

In consequence of Zittel's discovery of the jaws of *Conoclypeus*, it became necessary for A. Agassiz to take his species *C. Sigsbei* out of that genus and to establish one which would include it. This led to the description of the genus *Conolampas*, A. Agass., 1883. De Loriol found that some forms which had been considered to belong to *Conoclypeus*, but which he showed had neither perignathic girdle nor jaws, had a decided phyllode at the peristomial margin of each ambulacrum. For these forms

De Loriol established the genus *Phylloclypeus* in Mém. Soc. de Phys. et d'Hist. Nat. de Genève, 1880, vol. xxvii. p. 79.

The question arises, What is the difference between *Conolampas*, Agass., and *Phylloclypeus*, De Loriol? I cannot see that there is much structural difference of physiological importance between them. The question is complicated by De Loriol's decision that *C. Sigsbei*, A. Agass., "est certainement un *Echinolampas*," Cat. Rais. des Éch. rec. à l'Ile Maurice, Mém. Soc. Phys. et Hist. Nat. de Genève, vol. xxviii. p. 44 (1883). My study of the great series of *Echinolampas* in the Tertiaries of W. Sind clearly decides in my mind the classificatory importance of the unequal poriferous zones in the same ambulacrum; and I cannot admit in the typical genus *Echinolampas* forms with equal, long or short ambulacral zones. I demur, therefore, to the opinion of my friend, that *Conolampas* is an Echinolampad. I am content to believe that the two genera will come within the same alliance as *Palæolampas*, Bell, and *Microlampas*, Cotteau.

Genus PHYLLOCLYPEUS, *De Loriol*, 1880, *op. cit.* p. 79.

Syn.? *Clypeolampas*, Pomel, 1868, *fide* Pomel.

Test large, Conoclypeoid in shape and structure, except that there is neither a perignathic girdle nor jaws present. On the other hand, the floscelle is well developed and there are accessory plates in the phyllodes. Periproct oval, longitudinal, submarginal.

Fossil. Upper Cretaceous, *fide* Cotteau: Europe. Eocene: Europe, Africa, Asia.

Genus CONOLAMPAS, *A. Agassiz*, 1883, *'Blake' Ech., Mem. Mus. Comp. Zoöl. Harv.* vol. x. no. 1, p. 48, and 1888, vol. xv. p. 99 (*non* Conolampas, *Pomel*, 1883).

Syn. *Conoclypeus*, A. Ag. (non auct.), 1878, Bull. Mus. Comp. Zoöl. no. 9, p. 190, pls. 1, 2.

Test large, taller than broad, hemispherical above the almost circular margin; flat actinally.

Apical system small, projecting at the centrally placed apex; button-shaped; four basal plates perforated; the madreporite in the right anterior basal, and extending into the centre of the system, and separating the basals; five radial plates, small, and the postero-lateral in contact with the madreporite and separated by it.

Ambulacra narrow, similar, equal, straight, flush, widely open to the ambitus, the parts of the poriferous zones with paired pores widening and then diminishing to a point; pores beyond terminating much before the margin of the test is reached, in single series; close to the peristome there is some doubling of pores and a small phyllode. Ambulacral plates numerous, low, broad primaries.

Interradia large, with much fewer and taller plates than the ambulacra. Tubercles of both areas similar, very small, perforate, crenulate, sunken in scrobicules, a miliary structure between the scrobicules.

Peristome small, central, pentagonal, wider than long; phyllodes nearly crowded out by bourrelets. Perignathic girdle reduced to small knobs upon the interradia; jaws absent. Periproct inframarginal, small, elliptical, transverse, close to the posterior edge; with three large plates and some small ones. Spines short, slender, cylindrical, tapering.

Recent. Caribbean Sea, 76–460 fathoms.

The resemblance of the degraded perignathic girdle to that of *Echinoconus* is very suggestive.

Genus Plesiolampas, *Duncan & Sladen*, 1882, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pp. 9, 54, pls. i., xiii.–xv. (*non* Plesiolampas, *Pomel*, 1883, *Thèses*, p. 62).

The test is moderate in size, variable in shape, ovoid, elongate, or polygonal, depressed, tumid at the margins and dorsum, concave around the actinally placed peristome.

Apical system excentric in front, with four basal plates, perforated and united; madreporite in the right anterior, and extending into the others centrally, large and separating the posterior lateral radial plates slightly.

Ambulacra subpetaloid, widely open at the distal extremity; poriferous zones subequal, almost straight; pores round, the outer sometimes elongate. Poriferous zones continued on the actinal surface as single pores; a rudimentary phyllode.

Interradia large and broad in comparison with the ambulacra; tubercles numerous, small, mamillated, imperforate, and noncrenulated, in deep scrobicules; miliaries numerous.

Peristome central, subcentral, or excentric in front, subpentagonal or oval-elliptical, transversely elongate, with a very

rudimentary floscelle. Periproct moderately large, inframarginal, elongate oval, placed longitudinally.

Fossil. Eocene: Asia (Sind). Probably *Palæopneustes conicus*, Dames, 1877, of the Vicentin Eocene, belongs here.

Subgenus ORIOLAMPAS, Munier-Chalmas, 1882 (genus), *Bull. Soc. Géol. de France*, sér. 3, vol. x. p. 386. *Cotteau* (genus), 1887, *Pal. Franç., Éch. irreg. Terr. Eocène*, p. 499.

Plesiolampas with crenulate and perforate tubercles.

Fossil. Eocene: Europe.

Genus PALÆOLAMPAS, *J. Bell*, 1880, *Proc. Zool. Soc.* p. 43.

Syn. *Clypeolampas*, Pomel *.

Test moderate, thick, irregularly ovoid in tumid marginal outline, subconical and depressed dorsally, rather flat at the slightly precentral apex, slightly tumid actinally.

Apical system with four basal plates fused and the large madreporite central, four pores; radial plates small, and the pores variable in size.

Ambulacra rather broad, open, the pores remaining paired as far as the ambitus, the outer row of pores of each series of pairs continued over the ambitus to the peristome; a tendency to shortening of one of the paired poriferous zones only slightly indicated in the antero-lateral ambulacra. Ambulacra widest at the end of the double series of pores.

Interradia large, closely ornamented, and the interporiferous areas also with similar small primary tubercles.

* M. Pomel does not give any references in his work, Thèses, 1883, p. 65, and in the instance of his genus *Clypeolampas* merely states:—" *Clypeolampas*, Pomel, 1868 (*Phylloclypeus*, De Loriol, 1880)." Search has been made in vain for any such genus published in 1868 by M. Pomel, and it is necessary therefore to take the diagnosis given in the page just mentioned. Careful study of this diagnosis proves that it will include many Echinolampads, *Conolampas* (Pomel, as well as the different genus of A. Agassiz), *Hypsoclypeus*, Pomel, *Plesiolampas*, Pomel (*non* Duncan and Sladen), and *Palæolampas*, Bell. Its author was not aware of its being an edentate genus, because that was made out for all forms with phyllodes by De Loriol, and therefore this insufficiently-defined genus does not include *Phylloclypeus*, De Loriol.

M. Cotteau has lately published *Clypeolampas Lesteli*, Cott. 1887, Bull. Soc. Géol. de France, sér. 3, vol. xv. p. 662. Humbert's drawings of it show that it is a *Palæolampas*, Bell, with larger primary tubercles in the abactinal plates. The genus cannot stand.

Peristome slightly excentric in front, small, pentagonal, broader than long, with bourrelets and phyllodes feebly but definitely developed. Periproct elongated transversely, submarginal.

Fossil. Upper Cretaceous: France. Tertiary: Europe *.

Genus MICROLAMPAS, *Cotteau*, 1887, *Bull. Soc. Zool. de France*, p. 637, pl. x. figs. 10–13.

Test small, circular, tumid, subconical dorsally, flat, subpulvinate actinally.

Apical system central, the madreporite projecting centrally, with small radial plates.

Ambulacra becoming wider towards the ambitus, subpetaloid, open at their ambital extremity; poriferous zones composed of small unequal pores, appearing to be united by a groove, the outer pairs more elongate than the inner. At a considerable distance from the margin of the test the pairs cease, and a single row of pores is continued to the peristome.

Interradia more or less keeled close to the apex, the ornamentation similar to that of the ambulacra, not abundant, of small crenulate and perforate primary tubercles, largest at the ambitus and actinally.

Peristome deeply seated, pentagonal, with a slight floscelle. Periproct rounded in outline, flush, inframarginal.

Fossil. Eocene: Europe.

There is but one species, and it is small, but the affinities with *Palæolampas* and *Conolampas* are interesting.

Genus NEOLAMPAS, *A. Agassiz*, 1869, *Bull. Mus. Comp. Zoöl.* i. p. 271; 1872–4, *Revision of Echini*, p. 340. *Wyville Thomson*, 1874, *Phil. Trans.* vol. clxiv. p. 745.

Test small, thin, depressed, pyriform, arched above, truncated obliquely behind and rostrated, concave actinally.

Apical system in front of the highest point of the test, with four basal plates, three of which are perforated, and the madreporite is in the right anterior, and separating the basals 1 and 4 more or less.

* M. Pomel, 1883, Thèses, p. 62, has mistaken the meaning of *Palæolampas*, which he considers to be a subgenus of *Echinolampas*. He places in it *Echinolampas Hellei*, Val.; but this recent form has ambulacra differing from those of *Palæolampas*, and it is a true *Echinolampas*.

Ambulacra flush, apetalous; poriferous zones uniporous; pores in small plates near the peristome and crowded there, producing rudimentary phyllodes between slight bourrelets.

Peristome beneath the apical system, and slightly in front of the centre, depressed, indistinctly pentagonal. Posterior interradium slightly ridged and sinking gradually to the depressed truncation, which is occupied by the large marginal periproct, which is oval and plated with scales; an anal tube may exist.

Interradial plates large. Tubercles small and numerous, largest actinally, many on the bourrelets. Spines straight, not long, slender, smallest with a tip of pointed tubercles. Pedicellariæ long and short, tridactyle, mostly blunt. Spheridia large, numerous, naked.

Recent. Mouth of English Channel, and Caribbean Sea, 230–600 fathoms.

III. Family COLLYRITIDÆ.

Exocyclic nodostomes with apical systems disconnected and either elongate or subcompact. Ambulacra similar; bivium widely separated from the trivium; floscelle absent.

Genus *Collyrites.*
Dysaster.
Hyboclypeus.
Infraclypeus.
Grasia.

Genus COLLYRITES, *Des Moulins*, 1835, *Études s. les Echin.* p. 46. *Lovén*, 1874, *Études*, figs. 55–60, 98, 180.

Syn. *Dysaster*, Agass. (pars).

Test moderate and rather large, ovoid, oblong or cordiform in marginal outline, tumid, moderately high abactinally, depressed there or raised anteriorly, more or less narrowly truncated posteriorly, actinally flat, or irregularly swollen or concave.

Apical system elongate and dislocated; an anterior portion consisting of a small anterior radial plate and of the antero-lateral basal plates, separated from the posterior basal plates by the united antero-lateral radial plates; the posterior portion consisting only of the united postero-lateral radial plates. The portions are widely separated by numerous small plates belonging to the postero-lateral interradia; the madreporite in the right anterior basal plate.

Ambulacra disjunct and similar, the anterior in a slight groove or flush, the others flush, increasing in width to the ambitus, the pairs of pores in low primary plates; posterior ambulacra at varying distances from the anal groove. Interporiferous areas with small perforate and crenulate tubercles.

Interradia very unequal, broad; the postero-lateral areas uniting at the dorsum behind the postero-lateral basal plates.

Actinally the postero-lateral interradia are symmetrical, there being no fusion of plates. The interradial ornamentation is of the same kind as that of the ambulacra, but closer. Peristome pentagonal or subcircular, its margins formed by two unequal plates to each ambulacrum, and a single interradial plate to each area. Neither phyllodes nor bourrelets. Periproct posterior, in a groove at varying heights above the margin.

Fossil. Oolite: England and Europe, N. Africa. Cretaceous: Europe.

Genus Dysaster, *Agassiz*, 1839, *Éch. foss. d. l. Suisse*, vol. i. p. 1; 1847, *Ann. d. Sci. Nat.* vol. vii. p. 275 (Disaster). *Desor*, 1842, *Monogr. d'Éch. viv. et foss.* livr. 3, p. 7. *Cotteau*, 1885, *Éch. foss. de l'Yonne*, vol. i. p. 335; 1867–74, *Pal. Franç., Terr. Crét.* vol. ix. p. 106.

Test moderate, subcylindrical, long, low, rounded in front, truncated squarely posteriorly.

Apical system dislocated; the anterior part excentric in front, with the two pairs of basal plates in contact, the anterior and antero-lateral radial plates being external; the posterior part consisting of the postero-lateral radials united along the median line and separated from the anterior part by numerous small plates of the postero-lateral interradia; the madreporite in the right anterior basal plate, or extending between the postero-lateral basal plates.

Ambulacra disjunct, flush, increasing in width to the ambitus, the posterior may be flexuous; bivium and trivium widely separated; pairs in simple series. Postero-lateral interradia large, may have additional plates at the dorsum.

Peristome excentric in front, subpentagonal, plain; a single peristomial plate in each interradium. Periproct pyriform, in the posterior truncation, supramarginal.

Fossil. Europe, N. Africa.

This genus is distinguished from *Collyrites* by having the basal plates not separated by antero-lateral radial plates.

Genus Hyboclypeus, *Agassiz*, 1839, *Éch. Suisse*, pt. i. p. 74. *Wright*, 1856, *Pal. Soc.*, *Ech. Ool. Form.* p. 291, pls. xxi. & xxii.

Test moderate in size, ovoid, usually highest in front, gibbous, tumid, depressed, truncated and grooved posteriorly, swollen actinally.

Apical system subcentral, elongate; the antero-lateral radial plates uniting along the median line and separating the pairs of basal plates; a complementary plate or the fifth basal plate may separate the posterior basal plates; the anal groove separates the posterior radial plates.

Ambulacra disjunct, similar, flush, apetalous, the anterior sometimes in a groove and all more or less wavy. Poriferous zones narrow, and the pairs are in simple series, and close abactinally and at the margin, and wider apart and triserial at the peristome; plates low primaries abactinally, compound actinally.

Interradia wide, tumid, and the posterior with a long deep groove becoming wide and shallow at the truncated edge; periproct in the upper part.

Peristome excentric in front, deep, pentagonal, and longer than broad; no floscelle.

Tubercles close, uniform, small, perforate and crenulate; scrobicules sunken.

Fossil. England and Europe.

It is said that a compact apical system may occur, a complementary plate being between the pair of basal plates, and a similar plate is said to occur between the posterior pair of basal plates. It may be a matter of doubt whether the generic characters can vary so much.

Genus Infraclypeus, *Gauthier*, 1875, *Cott.*, *Peron & Gauthier*, *Éch. Foss. de l'Algérie*, 1876, fasc. ii. p. 23, pls. 14, 15.

Test large, more or less hemispherical, somewhat depressed, subcircular at the basal outline, slightly narrowest posteriorly, flat actinally.

Apical system subcentral, and at the highest point elongate; the antero-lateral radial plates uniting at the median line and separating the pairs of basals; posterior radials large, no fifth basal; the madreporite in the right anterior basal plate.

Ambulacra subequal, flush, apetaloid, similar, increasing in width to the margin, and thence diminishing towards the peristome. Pairs of pores in single series; pores small, oblique.

Anterior ambulacra straight, the antero-lateral wide apart and slightly curved. Actinally the ambulacra are in slight hollows of the test.

Interradia large, plates numerous, bent, low and broad.

Peristome in a slight concavity, oval, oblique, from right to left; without a floscelle or branchial incisions. Periproct inframarginal, elongate antero-posteriorly, ovoid or elliptical, in a groove, which is more or less continued abactinally. This groove seems occupied by small, elongate, distinct plates?

Fossil. Tithonian: Africa (Algiers).

The author considers that the genus is near *Pachyclypeus*, from which it differs in the position of the periproct and in the remarkable construction of the posterior groove. The obliquity of the peristome is in the opposite direction to that of *Amblypygus*.

Genus GRASIA, *Michelin*, 1854, *Rev. et Mag. Zool.* sér. 2, p. 439. *Cotteau*, 1867–74, *Pal. Franç., Terr. Jura, Éch.* vol. ix. p. 34.

Test large, twice as long as broad, oval, depressed, tumid dorsally and actinally, truncated posteriorly.

Apical system very dislocated and elongate, the basal plates separated by the union of the antero-lateral radial plates, the postero-lateral radial plates placed far back.

Antero-lateral ambulacra far to the front, and the postero-lateral far behind, placed above the periproct; apetaloid, flush, the anterior straight and the others flexuous.

Peristome central, circular, plain. Periproct in a deep posterior groove which reaches the dorsum.

Fossil. Oolite: Europe.

There are some genera which link the Cassiduloidea and the Spatangoidea in a very interesting manner, and the character of the *dissimilarity of the construction of the anterior and the paired ambulacra is always evident*, but not so much as in the true Spatangoids.

IV. Family PLESIOSPATANGIDÆ.

Tests variable in shape and in the presence of small floscelles; ambulacra short or long in the subpetaloid parts; apical system compact or elongate and disjunct. Odd ambulacrum with pores differing in shape from those of the lateral ambulacra, or they may abort.

Genus *Eolampas.*
Archiacia.
Claviaster.
Asterostoma.
Pseudasterostoma.
Metaporhinus.

Genus EOLAMPAS, *Duncan & Sladen*, 1882, *Foss. Echin. W. Sind* (*Pal. Ind.* ser. xiv.), pt. ii. p. 62, pl. xvii., and p. 150, pl. xxxi.; 1888, *Ann. & Mag. Nat. Hist.* ser. 6, vol. ii. p. 329.

Syn. *Petalaster*, Cotteau, 1884; *Pseudopygaulus*, Coquand, 1862, genus undes., only figured.

Test small, tumid, ovoid, subdepressed; the greatest height corresponding with the apical disk, and very excentric in front; the anterior slope rapid and precipitous, the posterior region subrostrate near the extremity.

Apical disk excentric in front, small; basals four, penetrated by genital ducts; madreporite central.

Ambulacra flush, small, short, petaloid, subequal; the odd anterior aborted. Poriferous zones of the other ambulacra subequal.

Peristome transversely oval, subcentral or very slightly excentric in front, with a perpendicular wall reaching upwards into the body-cavity. No bourrelets. Phyllodes very slightly developed. Buccal pores opening into the peristomial margin, with a small granule-like prominence over each, standing at the extreme edge of the peristomial ring. Periproct marginal, transversely oval. Tuberculation small, homogeneous, in sunken scrobicules; intermediate space subgranular and confluent.

The ambulacral rosette is small in relation to the size of the test, and the ambulacral petaloid ends terminate remotely from the margin of the test. The anterior ambulacrum has no double pores, and the grooves which are in their place do not present a single pore.

The interradial areas are largely developed abactinally. There is a faint groove in front of the sunken peristome. The periproct varies in its size and height in the posterior surface.

Fossil. Eocene of Asia (Sind); N. Africa (Algiers); Europe?

Genus ARCHIACIA, *Agassiz*, 1847, *Ann. d. Sci. Nat.* vol. vii. p. 101. *D'Orbig.* 1855, *Pal. Franç., Terr. Crét.* vol. vi. p. 283, pls. 909, 910. *Desor*, 1858, *Synopsis*, p. 324. *Cotteau*,

Peron, & Gauthier, 1879, *Éch. Foss. de l'Algér.* fasc. 5, p. 154, pls. x., xi. *De Loriol*, 1888, *Faune Crét. du Portug.*, *Éch.* vol. ii. fasc. 2, p. 83, pl. xv.

Test moderate or large, thin, ovoid in marginal contour, broadest posteriorly, high, subconical at the anteriorly placed and overhanging apex, sloping gradually elsewhere, more or less grooved anteriorly. Actinally plane or convex.

Apical system at the highest point, with four perforated basal plates.

Ambulacra diverse, flush; the odd one non-petaloid, and with a biserial arrangement of small oblique pairs of pores in each poriferous zone; other ambulacra short, subpetaloid, tending to close, with diverse pores, the outer elongate; pores single (?) beyond the subpetaloid parts and in high plates, the others in low and broad primaries.

Interradia broad, and the plates broad, rather low, and numerous. Ornamentation of small tubercles and granules.

Peristome large and widely open, excentric in front, more or less pentagonal, and with a rudimentary floscelle. Periproct large, ovoid, elongate longitudinally, submarginal.

Fossil. Cretaceous: Europe, N. Africa.

Genus Claviaster, *d'Orbigny*, 1855, *Pal. Franç.*, *Éch. Terr. Crét.* vol. vi. p. 281, pl. 909.

Syn. *Archiacia*, pars.

Test of moderate size, inordinately tall, finger-shaped. Apical system at the apex with four basal plates perforated.

Ambulacra very long, dissimilar, flush; the anterior with single pores in each zone, the other and paired ambulacra with slightly sunken pairs.

Fossil. Cretaceous: Asia.

The genus *Asterostoma* has given much trouble to MM. Cotteau and A. Agassiz. This may be seen by reading M. Cotteau's title of the genus in his Memoir in the Mém. Soc. Géol. de France, 1871–73, vol. ix. p. 177, and a passage in the Report on the 'Challenger' Echini, 1881, p. 167.

It must be admitted that A. Agassiz is quite justified in his remarks about the existence of more than one type in the genus *Asterostoma* as determined by M. Cotteau.

It is necessary to differ from M. Cotteau regarding the name

which should be placed after the genus, for there is no evidence that Lamarck wrote upon it. The genus first appeared in the Catal. rais., Ann. des Sci. Nat. vol. vii. p. 168 (1847). Agassiz there wrote:—"The genus links the Cassidulidæ and the Spatangoids; it has the shape of *Ananchites*, but differs from it in the mouth, which is median and pentagonal. The ambulacra are united together at the summit, and the odd one has the pairs of pores smaller and more distant than in the paired petals, almost like the Spatangoids. At the actinal surface the ambulacra correspond to broad and deep grooves. Anus posterior." The apex is evidently excentric in front. Agassiz defined the genus to include *Clypeaster excentricus*, Lam.

The next notice of the genus is in d'Orbigny's description of the Echinodermata, Pal. Franç., Terr. Crét. vol. vi. 1853–55, p. 279, pls. 906, 907, 908.

Genus Asterostoma, *Agassiz*, 1847, *Ann. d. Sci. Nat.* vol. vii. p. 168. *Cotteau*, 1871–73, *Mém. Soc. Géol. de France*, sér. 2, vol. ix. ii. p. 178.

The peristome is subpentagonal, not labiate, central or slightly in front. There are five actinal grooves from the peristome reaching the margin of the test, corresponding with the ambulacra. Anus posterior, marginal.

Ambulacra broad, subpetaloid, unequal; odd ambulacrum flush, with very small pores, circular and in simple series in regular pairs. Paired ambulacra flush, long, not contracting near the ambitus; pores simple, large, equal. Tubercles distant, scarce.

Fossil. Cretaceous?: Cuba.

The species is *Asterostoma excentricum*, Lam. sp., a very large form, 103 millim. long. It will be observed that the test is oval, longer than broad, broadest in front and slightly narrows behind; convex above, rounded in front, less so behind, tumid at the ambitus, flat actinally, with five grooves; ambulacra above the ambitus subpetaloid. In the plate 906. fig. 1 there is no anterior groove above the margin, and certainly the radial ends of the ambulacra are not sufficiently distant to enable any one to infer that the apical system was elongate. The species was probably *Echinolampas Kleinii.* There is no doubling of the pairs of pores at the peristome, and there is no sternum to the posterior interradium. On plate 908 the antero-lateral ambu-

lacra are seen to contract above the ambitus so as to present curved poriferous zones, and the small pairs commence close to the margin. The postero-lateral ambulacra do not contract, and are widest at the ambitus. All pores are circular.

These are perfectly recognizable definitions, and were reproduced to a certain extent by Desor, 1858, Synopsis, p. 196, pl. 37. The peristome is oval elliptical, and the small pairs of pores come regularly to its margins; but Desor makes the radial ends of the ambulacra so distant that there is room for a suspicion that the basal plates were separated by the antero-lateral radial plates. This is because of incorrect drawing.

M. Cotteau noticed the genus anew in Bull. Soc. Géol. de France, sér. 2, vol. xxiv. p. 826; but the diagnosis relates to a distinct type, which is now named *Pseudasterostoma.* The diagnosis is therefore accepted for the new genus as follows:—

Genus PSEUDASTEROSTOMA, gen. nov.

Syn. *Asterostoma* (pars), Cotteau.

Test large, more or less elongate, sometimes subcircular, swollen above, almost flat below.

Apical system moderately developed, subcircular; four basal and five radial plates; the antero-lateral basal plates touch within; the postero-lateral and the posterior pair of radial plates are separated by a complementary imperforate plate (this is the small imperforate fifth basal plate).

Ambulacra subpetaloid, unequal; the anterior different from the others in the structure of its pores. Poriferous zones of the paired ambulacra of different shaped pores, largely open abactinally, reduced in size suddenly near the ambitus, the pairs there being microscopical and very distant; near the peristome the pairs become larger, closer, and more or less pronounced, and converge to the mouth. Tubercles scarce, small, crenulate, perforate, and scrobiculate; granules in circles around the scrobicules. Peristome sublabiate, transverse, either central or very excentric in front; periproct rounded, flush, posterior, just above the margin.

Fossil. Cretaceous?: Cuba.

This generic definition does not notice the definite grooving of the actinal surface, the slightly contracting antero-lateral and the open postero-lateral ambulacra above the ambitus, the comparatively central position of the simple peristome, and the general

simplicity of the ambulacra characteristic of *Asterostoma*, Agass.

The terminology appears to be:—

Asterostoma excentricum, Lmk., sp.
„ *cubense*, Cott.
Pseudasterostoma Jimenoi, Cott., sp.

Genus METAPORHINUS, *Michelin*, 1854, *Rev. et Mag. de Zool.* sér. 2, p. 439; *Bull. Soc. Géol. de France*, sér. 2, t. i. p. 270. *Desor*, 1858, *Synopsis*, p. 210. *Cotteau*, 1860, *Pal. Franç.*, *Terr. Jura*, vol. ix. pp. 28 & 504. *Cotteau, Peron & Gauthier*, 1876, *Éch. foss. de l'Algér.* fasc. 2, p. 17.

Test of moderate size and large, oval, slightly longer than broad, subcordiform, sometimes dilated at the ambitus. Very tall, gibbous, and projecting upwards anteriorly, and grooved and oblique behind, sloping at the sides, actinally tumid, especially behind the peristome. Anterior groove variable.

Apical system excentric in front, elongate, partly compact and disconnected and posterior. The four basal plates in contact and the posterior radial plates widely separated. The anterior radial plate may separate the antero-lateral basals.

Ambulacra, bivium disconnected from the trivium; diverse, apetaloid, flush, except the anterior, and this in a more or less defined groove, with simple, small, distant pairs of pores; paired ambulacra flexuous, pairs of pores becoming distant at the ambitus and numerous near the peristome; pores comma-shaped, placed obliquely to one another, or circular.

Postero-lateral interradia either uniting along the median line above or having plates intercalated there.

Peristome excentric in front, transversely elliptical-subundulate at its margin. Periproct supramarginal, either flush or in the upper part of a groove, and sometimes beneath an expansion of the test, oval or pyriform, acuminate above. Tubercles very small, crenulate and perforated, subscrobiculate; granules small, homogeneous, especially abactinally.

Fossil. Jurassic and Cretaceous: Europe. Tithonian: N. Africa.

VII.

The Suborder Spatangoidea and Families. Family Ananchytidæ and Genera, its Subfamily Urechininæ and Genera. Family Spatangidæ and its divisions, the Adetes and Genera; the Prymnadetes and Genera; the Prymnodesmia and Genera; the Apetala and Genera. Family Leskiidæ and Genus. Family Pourtalesiidæ and Genera.

II. Suborder **Spatangoidea.**

Exocyclic nodostomes, with the peristome excentric in front, rarely pentagonal in the adult, usually with a posterior labrum, behind which is a long plastron, either with a meridosternum or an amphisternum, bounded laterally by the posterior ambulacra. Periproct posterior, and either inframarginal, supramarginal, or marginal. Apical system with four perforated basal plates, compact, or the madreporite may vary in its extension, or elongate. Ambulacra dissimilar. Tentacles heteropodous, either simple, branchial, or penicillate or disciferous. Interradia with a single peristomial plate; the postero-lateral areas usually unsymmetrical actinally. Spheridia numerous. Fascioles present or absent.

I. *Family* ANANCHYTIDÆ.
II. " SPATANGIDÆ.
III. " LESKIIDÆ.
IV. " POURTALESIIDÆ.

I. Family ANANCHYTIDÆ.

Tests ovoid or subcordiform in marginal outline, tall or depressed; with or without an anterior groove; plates large. Apical system elongate or semi-disjunct; the madreporite in the right anterior basal plate, rarely diffused.

Ambulacra in a bivium and trivium, similar or slightly diverse, flush, apetalous; pairs of pores largest near the apex and at the peristome, may be uniporous.

Interradia all entering the peristome with a single plate, the postero-lateral unsymmetrical actinally, the posterior with a labrum and a long many-plated meridosternum, tuberculate and bounded by broad ambulacra.

Periproct either posterior, marginal, inframarginal, or supramarginal.

Ornamentation small. Tentacles heteropodous. A marginal fasciole may exist.

Genus *Echinocorys.*
  Subgenus *Jeronia.*
Genus *Holaster.*
  Subgenus *Lampadaster.*
Genus *Offaster.*
  Hemipneustes.
  Cardiaster.
  Subgenus *Infulaster.*
Genus *Hagenowia.*

Subfamily *Urechininæ.* Ambulacra uniporous.

Genus *Urechinus.*
  Cystechinus.
  Calymne.

Incertæ sedis: *Enichaster.*
  Stenonia.

Genus ECHINOCORYS, Breynius, 1732, *Sched. de Ech.* p. 58, pl. iii. fig. 2. *D'Orb.* 1853, *Pal. Franç., Terr. Crét.* vol. vi. p. 62. *Lovén,* 1874, *Études,* figs. 51–53, 97, 181.

Syn. *Ananchytes,* Lmk.; *Oolaster,* Laube, 1869.

Test large, thin, oval in marginal outline, flat actinally, straight or tumid at the sides above the sharp margin, high, rounded, or keeled apically.

Apical system elongate; usually the four basals are all perforated by genital ducts; but the foramen may be absent in the plate with the madreporite, or the right anterior basal plate; the antero-lateral radial plates large and united and separating the anterior and posterior pairs of basal plates.

Ambulacra nearly similar, all flush, apetalous, biporous, the plates low and narrow near the apex and gradually increasing in width and height to the margin, and small and dissimilar at the peristome; pairs of pores well developed abactinally; pores round or oval and nearly horizontal, becoming smaller, closer, and oblique towards the ambitus, where the pairs are more distant; at the peristome the adoral pore of a pair is in front of the aboral pore and separated by a nodule. Posterior ambulacra actinally long and broad, the pairs small and the pores oblique.

Interradia with large plates; the postero-lateral areas unsymmetrical actinally, from union of the second plates of both zones behind the peristomial plate of the right posterior area; all the

interradia enter the peristome with single plates, and that of the posterior is a labrum, behind which is a many-plated meridosternum forming a long plastron.

Peristome excentric in front, transversely oval; phyllodes moderately developed. Periproct inframarginal, posterior, oval.

Ornamentation of scanty small primary tubercles and numerous small granules; spines short and small.

Fossil. Upper Cretaceous: England, Europe, Africa.

Subgenus Jeronia, *Seunes*, 1888 (genus), *Bull. Soc. Géol. de France*, sér. 3, vol. xvi. p. 809.

Test large, subrostrate behind. Ambulacral plates broad and large. Apical system may have an accessory plate and only three genital pores. Some large tubercles near the ambitus.

Fossil. Cretaceous: Europe.

Genus Holaster, *Agassiz*, 1840, *Catal. Syst.* p. 1; 1847, *Ann. d. Sci. Nat.* sér. 3, vol. viii. p. 26. *Desor*, 1858, *Synopsis*, p. 336. *Pictet*, 1872, *Pal. Suisse, Éch. Crét.* p. 292. *Lovén*, 1874, *Études*, p. 49, pls. v. & xxv.

Syn. *Guettaria*, Gauthier, 1887; *Entomaster*, Gauthier, 1887.

Test variable in size, thin, ovoid in marginal outline, flat actinally, tumid and high, and may be keeled abactinally; a very broad and shallow groove anteriorly.

Apical system elongate; the madreporite in the right anterior basal plate.

Ambulacra apetalous, biporous, diverse; the anterior ambulacrum with pairs of small, oblique, circular or slightly elongate pores in the groove; the antero-lateral ambulacra the most divergent, their pores oblique, diverse, circular and linear, rather long; the pairs of the anterior and posterior zones may differ in size; the postero-lateral similar to the antero-lateral abactinally, like them also in having minute wide-apart pairs at the ambitus, but differing in being long and broad on the sides of the actinal plastron.

Interradia with large plates; the postero-lateral area of the right side actinally has the second plates of both zones beyond the single peristomial plate united, and is thus unlike the corresponding area of the left side; the peristomial plate of the posterior interradium is broad and larger than the others, it forms a labrum and is succeeded by a long many-plated meridosternum, but the

second plate of this stretches across and occludes the fellow plate from the peristomial plate.

Peristome excentric in front, elliptical and broadest transversely. Periproct supramarginal, oval.

Ornamentation of small primary tubercles raised above the general surface; granules exist in numbers and limit the plain scrobicules.

Fossil. Cretaceous: England, Europe, Asia, W. Africa. Miocene: Australia.

It is hardly possible for *Holaster Campicheanus*, d'Orb., to remain in the genus, and *H. Indicus*, Forbes, may be a *Cardiaster*.

Subgenus LAMPADASTER, *Cotteau*, 1889 (genus), *Bull. Soc. Zool. de France*, vol. xiv. p. 88.

Appears to be an *Holaster* with a pronounced ambulacral groove at the ambitus anteriorly, with large, distant, broadly scrobiculate tubercles especially abundant dorsally; the periproct below a posterior rostration.

Fossil. Cretaceous: Madagascar.

Genus OFFASTER, *Desor*, 1858, *Synopsis*, p. 333. *De Loriol, Éch. des Env. de Camerino*, 1882, p. 10. *Lovén*, 1883, *Pourtalesia*, p. 92. *Gauthier*, 1887, *Bull. Soc. d. Sci. de l'Yonne*, vol. xli. *e* (pub. 1888), p. 403.

Test small, tumid, globose or conical or cordiform, flat or tumid actinally.

Apical system elongate; the madreporite in the right anterior basal plate. A doubtful or absent anterior groove.

Ambulacra flush, apetalous, with few high plates with minute circular pores in pairs, which diminish in size and increase in distance towards the ambitus, and are larger at the peristome.

Interradial plates high, larger than those of the ambulacra; the postero-lateral areas unsymmetrical actinally on account of the fusion of the second plates of the right posterior area; a narrow posterior peristomial plate with a small labrum, and posteriorly is a long meridosternum.

Peristome excentric in front, broader than long, oval. Periproct circular or ovoid, supramarginal. A marginal fasciole may occur.

Fossil. Cretaceous: England and Europe.

Certainly no forms with compact apical systems can enter.

Genus Hemipneustes, *Agassiz*, 1840, *Cat. Syst.* p. 2; 1847, *Ann. d. Sci. Nat.* vol. viii. p. 31. *Desor*, 1858, *Synopsis*, p. 348. *Lovén*, 1883, *Pourtalesia*, pp. 70, 92, 95.

Test large, ovoid in marginal outline, high and tumid, and raised or not in front abactinally, flat actinally; narrowly and deeply grooved anteriorly and more or less emarginate posteriorly.

Apical system central, elongate; the antero-lateral radial plates large and uniting at the median line; the madreporite diffused.

Ambulacra dissimilar; the anterior in the groove, its plates and pairs of pores numerous and small, the rows of pores wide apart; the paired ambulacra flush, semipetaloid, more or less curved, open distally, with numerous plates; the pores of the pairs circular and elliptical and elongate.

Interradia actinally symmetrical on account of the fusion of the second plates of both of the postero-lateral areas. Posterior interradium with a wide produced labrum and a meridosternous plastron with large plates and a zigzag of sutures.

Peristome excentric in front, much sunken, crescent-shaped, broad. Periproct supramarginal. A small equal granulation, large on the edge of the anterior groove.

Fossil. Cretaceous: Europe, Africa.

Genus Cardiaster, *Forbes*, 1852, *Mem. Geol. Survey*, Decade iv. pl. ix. *Desor*, 1858, *Synopsis*, p. 344.

Syn. *Stegaster*, Pomel (pars); *Cibaster*, Pomel (pars).

Test large, cordiform, slightly convex actinally, tumid at the margin and rather depressed abactinally, broader than high, may be high anteriorly; with a well-marked anterior groove keeled at its sides, reflected more or less on the dorsum.

Apical system subcentral or excentric in front, elongate, the anterior basals being separated from the postero-lateral by the united antero-lateral radials. Madreporite in the antero-lateral basal plate.

Ambulacra apetalous and biporous, flush with the surface of the test except the anterior, which is in the anterior groove. Anterior ambulacrum with small pores, the pairs becoming wider apart vertically and horizontally, from increased dimensions of the plates, and reaching far down the groove, before they become smaller. The posterior poriferous zones of the other ambulacra have larger pairs of pores than their anterior zones; pores elongate, and often placed obliquely in the pairs.

Interradia with large plates, the plates behind the peristome forming a meridosternum.

Peristome excentric in front, and its orifice with a posterior lip looking forwards, elliptical, transverse. Periproct in a depression in the truncated posterior face, oval. A more or less complete marginal fasciole passing below the periproct.

Fossil. Lower Greensand to White Chalk: England, Europe, Asia, America.

Such forms of *Cardiaster* as *C. fossarius*, Benett, sp., from the Upper Greensand, *C. Cotteauana*, d'Orb., besides a variety of the first-named species, lead so decidedly up to *Infulaster*, Hagenow and Desor, that after due consideration I agree with Forbes in placing the species which were admitted by Hagenow, d'Orbigny, and Wright in that genus, with one exception, in the genus *Cardiaster*; or rather in a subgenus without a fasciole (*Infulaster*). I have examined the types described by Forbes, and they have no lateral or any kind of fasciole, and this was the opinion of the late Dr. Wright. All the characters of *Cardiaster* are present in the species *C. excentricus*, Forbes, and therefore the absence of the fasciole is not of generic importance. I do not consider that *Cardiaster rostratus*, Forbes (the *Infulaster rostratus* of Desor), belongs to the genus, and I admit it in a new one, *Hagenowia*.

Subgenus INFULASTER, *Hagenow* (genus), 1851; *Desor*, 1858, *Synopsis*, p. 347.

Test high in front, narrow; anterior groove deep and with strong lateral keels. Fasciole absent.

Fossil. Upper Chalk: England and Europe.

Genus HAGENOWIA, gen. nov.

Syn. *Cardiaster*, Forbes (pars); *Infulaster*, Desor (Hagen.) (pars); *Stegaster*, Pomel (pars).

Test small, long, narrow ovoid, low, with a long, slightly bent, blunt-pointed rostrum, grooved beneath and arising from the upper and anterior part of the test *. The narrow dorsum of the test is saddle-shaped, short, and slopes from the rostrum to the oblique posterior truncation, which is narrowly grooved from below upwards. The anterior part of the test, beneath the

* See Forbes, 1852, Mem. Geol. Survey, Decade iv. pl. x. fig. 7.

rostrum, is nearly vertical, narrow, and grooved. Actinally the test is narrower than dorsally, and is convex from before backwards and from side to side.

Apical system small, on the top of the rostrum; there are four basal plates * placed closely, and the anterior pair are alone perforated by genital ducts. Radial plates small.

Ambulacra apetalous, and, with the exception of the anterior, which is in the anterior groove †, flush with the test. Pairs of pores of the anterior ambulacrum few and wide apart, continued up over the end of the rostrum abactinally. Pairs of the antero-lateral ambulacra small and indistinct, passing down the rostrum abactinally ‡, and keeping close to the edge of the anterior part of the test; the postero-lateral pair passing parallel to the ridge of the dorsum to close to the oblique posterior edge, and then passing downwards to reach the actinal surface far back, and running along the convex median part on either side to the excentric in front peristome.

Peristome § at the end of the anterior groove, transversely elliptical; posterior interradium meridosternous behind the peristome. Periproct ‖ at the top of the posterior groove.

Ornamentation small, scarce, made up of close miliaries. Primary tubercles absent. Fascioles absent.

Fossil. Upper Chalk: England, Europe.

HAGENOWIA ROSTRATUS, *Forbes*, sp., 1852, *Mem. Geol. Survey*, Decade iv. p. 3, pl. x.

Test compressed at the sides, with the apex produced as an elongate, oblique, slender rostrum.

Subfamily *Urechininæ.*

Ambulacra uniporous.

The genus *Urechinus*, A. Agass., has had its solitary species well studied by its first describer, and also by Lovén; but it must be admitted that the shape and details of *U. Naresi* (*Naresianus*, A. Ag., is probably not classical, as "Nares" refers to a man and not to a place), given in the 'Challenger' Report, pls. xxix., xxx., xxx. *a*, are not those of the one species. Some forms have and others have not a subanal fasciole; and these last are,

* Plate x. fig. 11. † Figs. 8 and 9.
‡ Fig. 10. § Fig. 13. ‖ Fig. 12.

moreover (as Lovén has pointed out), without the peculiar arrangement of the pores of the postero-lateral ambulacra in the subanal region, which is seen invariably with a true subanal fasciole.

It may be that there are two groups of forms, one without and the other with a subanal fasciole, and yet closely allied, as in the instance of *Micraster* and *Epiaster*; or the fasciole may be so small in the area which it surrounds, that it does not interfere with the ambulacra. The final solution of these questions must be left to the distinguished author of the Report on the 'Challenger' Echini; but for the present the latest authority, Prof. Lovén, must be consulted.

Genus Urechinus, *A. Agassiz*, 1879, *Proc. Amer. Acad.* vol. xiv. p. 207; 1881, *Report on the 'Challenger' Echini*, p. 146, pls. xxix., xxx., xxx. *a*; 1883, *Report on the 'Blake' Echini*, p. 52, pl. xxvi. *Lovén*, 1883, *Pourtalesia*, p. 90, pl. xxi.

Test moderate in size, ovoid, tumid, tapering posteriorly in marginal outline, varying in height, either low, tumid, and feebly arched dorsally, or conical and taller than broad; convex actinally, with a slight keel over the region behind the peristome, truncated posteriorly, and with a hood overhanging the periproct; surface smooth.

Apical system nearly central, elongate, the lateral basal plates separated by the junction of the antero-lateral radial plates, with or without complementary plates; usually three genital pores; and the madreporite in the right anterior basal plate, but there may be a fourth pore; posterior basal plates united; radial plates irregular in shape.

Ambulacra all flush, apetalous, uniporous; the plates high, and differing little from those of the interradia, except those of the anterior, which are lower and more numerous; pores small.

Interradia with the postero-lateral areas broadest; actinally the single peristomial plates small and narrow, the labrum also and not prominent; the whole of the paired areas symmetrical; the second plates of both zones of each lateral interradium united so as to form a single plate beyond the peristomial plate; the third plates separate. The sternum semimeridosternous (the plate 2 of zone *b* occupying the whole sternum, and followed by a small plate 2 of zone *a*, and at its side a plate 3 of zone *b*).

Peristome subcentral in front, slightly sunken, subpentagonal;

the ambulacra form the larger part of the margin; membrane with a central mouth surrounded by concentric buccal plates without tentacles, largest at the margin. Periproct low down in the posterior interradium, with a swelling below and more or less of a hood above, elliptical, its membrane with concentric plates. Below the periproct a mass of small miliary tubercles, which may simulate a fasciole. Tuberculation scanty, of primaries, with many secondary tubercles and miliaries; and hence a dense covering of very short spines, with broad bases.

Recent. 422 to 1800 fathoms, Pacific, south of equator, to Kerguelen, Magellan Strait, Caribbean Sea.

Genus CYSTECHINUS, *A. Agassiz*, 1879, *Proc. Amer. Acad.* vol. xiv. p. 207; 1881, *Report on the 'Challenger' Echini*, p. 148. *J. W. Gregory*, 1889, *Quart. Journ. Geol. Soc.* vol. xlv.

Test very large, thin to rather stout, may be flexible, ovoid or elliptical in tumid marginal outline, tall, subconical or subhemispherical, and then low; flat actinally, sunken slightly around the peristome, and tumid behind it.

Apical system subcentral or slightly posterior, elongate, plates confused; the pairs of basal plates separated either by large radial or by accessory plates; the basals large, irregular, and three, rarely four, perforated; a small madreporite in the right anterior basal; radial plates confused, some small.

Ambulacra similar, flush, apetalous, uniporous except close to the peristome, widening to the ambitus, with, as a rule, large plates, except close to the apex, where they are narrow.

Interradia with large plates tending to become hexagonal, very similar to ambulacral plates; a small peristomial plate to each area, and a meridosternum slightly tumid.

Peristome circular or subelliptical, transverse, in front of the centre, nearly flush, without lips, and with a raised internal ridge; peristomial membrane with concentric plates carrying small spines; mouth subcentral, in the membrane. Actinal tentacles tufted. Periproct elliptical, variably placed, marginal, and just above or below it; plates of membrane numerous.

But few primary tubercles on the plates, which may have ridges; many secondary tubercles and miliaries; spines short, very close and equal, some serrate and cylindrical, others club-shaped and spinulose. Pedicellariæ numerous, some on stalks, tridactyle, blunt or sharp-headed, mostly trefoil-like and sharp.

Fossil. Tertiary (late): Barbadoes.

Recent. Philippines; Tristan da Cunha to Buenos Ayres; Juan Fernandez to Chili; Antarctic Ocean, Marion Island to Kerguelen and Australia. Depth 1050 to 2225 fathoms.

Genus CALYMNE, *Wyv. Thomson*, 1877, *Voy. of the 'Challenger,' "The Atlantic,"* vol. i. p. 397. *A. Agassiz*, 1881, *Report on 'Challenger' Echini*, p. 154. *Lovén*, 1883, *Pourtalesia*, p. 90. (*Arranged.*)

Test moderate, and probably large in size, and very thin, oval elliptical in marginal outline, longer than broad, and broader than high, rather flat actinally, with a low rounded keel extending from the peristome backwards, tumid above the slightly sharply-edged margin, rather flat abactinally. Plates numerous, large, very geometrical in shape.

Apical system with the bivium widely separated from the trivium by plates of the postero-lateral interradia; anterior basals perforated by the genital ducts which protrude; the madreporite is placed immediately behind the basals 2 and 3, and is probably in an intercalated plate. Behind the madreporite are two large plates, one on either side of the median line; and they appear to be imperforate basals; and behind these basals are four or five plates of the postero-lateral interradia. The anterior radial plate is in the usual place and is small; the antero-lateral radials are on the outer edge of the large basals behind the madreporite; and the posterior radials are close and behind the last of the intercalated interradial plates. The system is therefore elongate and disunited. Basal 5 is absent.

Ambulacra flush, apetelous, uniporous; plates large and high, differing but slightly in height from the interradial plates, the pore being far in the middle of the plates. The anterior ambulacrum resembling the others and, like them, flush with the test; the antero-lateral far forwards and on a line with the peristome; the postero-lateral far back abactinally, and with broad parts on either side of the sternum.

Interradia with the anterior pair much smaller than the postero-lateral, which are broad and which separate the bivium from the rest of the calyx abactinally; the antero- and postero-lateral interradia reach the peristome, with very narrow single plates. Posterior interradium narrower than the postero-lateral, actinally forming the low keel of the sternum, its first plate

at the peristome is small, and the next is larger and single, the arrangement being meridosternous; the plates are slightly produced backwards so as to form a slight beak-like structure which is placed below the periproct.

The peristome is far in front and is pentagonal; it has irregularly concentric rows of plates on its membrane. Periproct nearly circular in outline, largely plated, and placed above the keel-like margin of the posterior part of the test. A narrow marginal fasciole exists, and it dips below the edge anteriorly.

The ornamentation of the test is small and simple, the two or three small primaries, which are on each ambulacral and interradial plate abactinally, are irregularly placed, and there are some granules with them; there are larger tubercles which are rather crowded along the sternal keel, and also on the posterior part of the abactinal surface. In these places the spines are largest and paddle-shaped and striated; similar spines are also around the periproct. The tubercles elsewhere carry slender hair-like or blunt-ended and notched spines. Colour of the test pale green.

Recent. North of Bermuda, 2650 fathoms.

Genera incertæ sedis: *Enichaster.*
Stenonia.

Genus ENICHASTER, *De Loriol*, 1882, *Descr. des Échinides des Env. de Camerino, Mém. Soc. Phys. et Hist. Nat. de Genève*, t. xxviii. No. 3, p. 30.

The test is much longer than broad, oval-elliptical in marginal outline, without notches; slightly convex dorsally and actinally, moderate in size and greatly depressed.

The apical system is excentric in front, compact, and has four close, perforated basal plates. Madreporite surrounded by the basals, and very small.

Ambulacra flush with the test, showing no tendency to closing; the anterior has no groove, and is composed of very minute pores which are wide apart. The antero-lateral ambulacra are almost transverse, and the poriferous zones are equal; the pores are in simple pairs, round, and not united by a groove. The posterior ambulacra are the longest and closest.

The excentric-in-front peristome was probably pentagonal. The periproct opens quite at the summit of the posterior inter-

radium. The tubercles are well developed, wide apart, scrobiculate, and are over the whole surface of the test, and there are small close granules.

Fossil. Eocene (Oligocene): Europe.

Genus STENONIA, *Desor*, 1858, *Synopsis*, p. 333.

Large conical Urchins, with the periproct inframarginal, a bilabiate peristome, and with equal ambulacra. The apical system is compact. The ambulacral plates are about half of the height of the interradial plates.

Fossil. Upper Chalk: Europe.

There is but one species known of this remarkable genus, which Desor pointed out is *Echinocorys* (*Ananchytes*) with a compact apical system; he notices that the test is very thick, and that there is a bulging of the centres of the plates.

II. Family SPATANGIDÆ.

Tests ovoid or cordiform, longer than broad, with numerous plates, and usually with an anterior groove.

Apical system with four or less perforated basal plates, compact, or with the madreporite variable in its posterior extension; radial plates five and external.

Ambulacra in a bivium and trivium, the anterior differing in shape and construction from the others, which may be petaloid dorsally or apetaloid, biporous, or uniporous; the postero-lateral long actinally and bounding the actinal plastron. Peripodia large around the peristome, forming rudimentary phyllodes, the tentacles being penicillate there, and either simple or branchial above.

Pairs of pores of the petaloid parts differing from the others.

Interradia narrow at the apex and at the peristome, where each has a single plate: the posterior plate the largest, and forming a labrum more or less projecting behind the transversely elliptical peristome. The postero-lateral interradia are usually unsymmetrical actinally, and the actinal plastron of the posterior area may be amphisternous or meridosternous.

Periproct in the posterior interradium. Fascioles present or absent. Spines slender. Spheridia most numerous in the bivium.

Unisexual or bisexual, undergoing free metamorphoses or not.

It has often been attempted to arrange the very numerous genera, both fossil and recent, of this Family into subfamilies, but with very doubtful success, on account of the presence of intermediate forms.

The researches of Lovén have indicated that the least artificial method of classification, and one which is comparatively natural, is to rely upon the subanal fasciole and its complementary modifications of the posterior ambulacra and their tentacles as a taxonomic character of importance, and to consider the other fascioles in a secondary sense.

Division I. The *Adetes*. All fascioles absent.
II. The *Prymnadetes*. Subanal fasciole absent, other fascioles present.
III. The *Prymnodesmia*. Subanal fasciole present.
IV. The *Apetala*. Tests with flush, apetalous, usually uniporous ambulacra.

I. Division *Adetes*.

Genus *Isaster*.
Epiaster.
Subgenus *Macraster*.
Genus *Echinospatagus*.
Ennalaster.
Heterolampas.
Megalaster.
Hemipatagus.
Platybrissus.
Palæopneustes.

Genus Isaster, *Desor*, 1858, *Synopsis*, p. 359. *De Loriol*, 1888, *Pal. de la Province d'Angola, W. Africa, Éch.* p. 118, pl. viii.

Test moderate in size, elongate, cordiform, largest in front, contracted posteriorly.

Apical system compact, slightly excentric in front.

Ambulacra slightly diverse, in shallow depressions, long, subequal; the anterior with smaller pores than the others, its pores elongate, forming a subpetaloid open area; the posterior ambulacra resembling the anterior pair, but less divergent, the pores

of the outer rows elongate, and those of the inner nearly circular; petals not closed.

Interradia large, and the tubercles distant, small, and projecting, mamillate, perforate, and crenulated.

Peristome excentric in front, large, and with a posterior labrum. Periproct flush, broadly ovoid, acuminate above and below, supra-marginal. Fascioles absent.

Fossil. Cretaceous: Europe, W. Africa.

There is no doubt that the genus *Epiaster* contains species which belong to *Micraster*, the subanal fascioles of which are not visible, and some to *Hemiaster*. *Epiaster de Lorioli*, Wright, of the English Upper Greensand, when well preserved has a distinct peripetalous fasciole, and is a large, squat *Hemiaster*. This was known to Bone the artist; but Dr. Wright could not see the fasciole, which is very apparent in the type specimen in the British Museum. Cotteau desired to unite the genus with *Micraster*; but there are true species of *Epiaster* without a sub-anal fasciole, and without the invariably concomitant modifications produced by that fasciole, in the plates and pores of the posterior ambulacra, so well described by Lovén in his 'Études.'

Genus Epiaster, *d'Orbigny*, 1853, *Pal. Franç., Terr. Crét. Éch.* vol. vi. p. 186.

Test moderate and large in size, cordiform in marginal outline, rather tumid and moderately high, or depressed and much broader than high, with an anterior groove, a rather narrow posterior truncation, and a tumid actinal surface posteriorly.

Apical system subcentral, with four perforated basal plates, and the madreporite usually separating the posterior basal plates, or it may be within the right anterior basal plate.

Ambulacra diverse, the anterior in the groove, with pairs of small pores on either side; paired ambulacra petaloid dorsally, long, unequal, sunken, straight, divergent, tending to close or not; pores elongate and unequal.

Interradia tumid dorsally.

Peristome transverse, excentric in front, the labrum projecting. Periproct oval, longitudinal, supramarginal, placed in a definite area. Tubercles small, perforate and crenulate, with intervening miliaries, largest near the margin actinally and upon the sternum.

Fossil. Cretaceous: England, Europe, S. Hindostan, W. Africa.

Subgenus MACRASTER, *F. Roemer* (genus), 1888, *Neues Jahrb. f. Min. u. Geol.* Bd. i. p. 191, pl. vi.

Peristome without a projecting labrum.

Fossil. Cretaceous: Texas, N. America.

Breynius certainly placed several species belonging to very different genera in his *Echinospatagus*; but Agassiz in 1840 failed to produce a homogeneous group in *Toxaster*, which he considered to be a good genus and to supersede that of Breynius. Since the date of the Catal. Rais., some authors have followed Agassiz and others Breynius. At the present time it would be justifiable to reject both of the generic terms, but it is as well to give Breynius credit for recognizing a very interesting form before the days of Agassiz.

Genus ECHINOSPATAGUS, Breynius, 1732, *Schediasma de Ech.* p. 61, pl. v. figs. 3, 4 (pars). *Lovén*, 1874, *Études*, p. 58 1883, *Pourtalesia*, p. 92.

Syn. *Toxaster*, Agassiz, 1840 (pars); Desor, 1858, Synopsis, p. 350; De Loriol, 1888 (*Toxaster*), Faune Crét. du Portug., Éch. ii. fasc. 2, p. 92. *Miotoxaster*, Pomel.

Test of moderate size, thin, broadly ovoid or subcordate in tumid marginal outline, broadest anteriorly, depressed, swollen dorsally and highest posteriorly, with an anterior shallow, broad groove and a posterior truncation.

Apical system excentric posteriorly, rarely central, with four perforated basal plates; the madreporite in the right anterior basal plate, and extending sometimes centrally, but not separating the posterior radial plates.

Ambulacra diverse, the anterior in the groove; the pairs of pores close vertically, and the pores unequal, those of the outer row the longest. Paired ambulacra unequal, subpetaloid, open, flexuous, very slightly sunken or flush, with unequal poriferous zones, and the pores of pairs unequal, the outer elongate and longer than the inner pores; pairs varying in width, and narrowing towards the end of the petals. Anterior paired ambulacra divergent but directed forwards; the anterior poriferous zones with smaller pairs of pores than the posterior zones. The postero-lateral ambulacra shorter than the others,

open, and the pairs of pores of the anterior zones smaller than those of the posterior.

Interradia tumid, the right posterior interradium actinally with normal heteronomy, the plates 2 and 3 of zone *a* being united; a sternum not quite symmetrical, but still amphisternous, and no true episternum.

Peristome excentric in front, subcircular or pentagonal, transverse; a small posterior labrum. Periproct in the posterior truncation. Tubercles distinct, small.

Fossil. Cretaceous: England, Europe, N. Africa, Asia (Syria).

De Loriol has proved the identity of *Ennalaster* and *Heteraster.*

Genus ENNALASTER, d'Orbigny, 1853, *Pal. Franç.* vi. *Terr. Crét. Éch.* p. 181. *De Loriol*, 1884, *Rec. Zool. Suisse*, i. no. 4, p. 622; 1888, *Faune Crét. du Portug.*, *Ech.* ii. fasc. 2, pp. 87–92, pls. xvi. & xvii.

Syn. *Heteraster*, d'Orb. 1853.

Test of small or moderate size, cordiform, low, tumid, slightly longer than broad, grooved in front, truncated behind.

Apical system compact, coinciding variably with the apex, may be excentric; four basal plates; the madreporite large, and separating or not the posterior basal plates.

The ambulacra diverse, the anterior broad in the slight anterior groove of the test, the broad pairs of pores close in vertical succession, numerous, a larger pair alternating with a small pair; the outer row of pores of the larger pairs elongate, and the inner smaller and shorter; intermediate small pairs either with elongate or circular outer pores, but always smaller than the others.

Petaloid parts of the antero-lateral ambulacra divergent, flexuous, tending to close, nearly flush, the poriferous zones unequal, the posterior the largest, anterior zone may be small; postero-lateral ambulacra short, divergent, zones unequal or not.

Peristome excentric in front, labiate, wide, arched in front. Periproct in the posterior truncation.

There are no fascioles.

Fossil. Cretaceous: England, Europe, N. Africa, Asia (Syria).

A careful comparison of the species of *Echinospatagus* and *Ennalaster* leaves great doubts in the mind whether the dif-

ferences in the pairs of pores of the odd ambulacrum—the essential distinction—are sufficient to separate the genera. De Loriol has expressed his doubts, but is content to permit the distinction to persist at present. It is not possible, however, to admit *Miotoxaster*, Pomel, although De Loriol names species with the title in his 'Faune Crét. du Portug.'

The position of the next genus is doubtful, and it would at first sight not be considered a Spatangoid; but Humbert's drawing shows some very definite characters.

Genus HETEROLAMPAS, *Cotteau*, 1862, *Rev. et Mag. de Zool.* sér. 2, vol. xiv. p. 198, pl. ix.; *Cotteau, Peron & Gauthier*, 1881, *Éch. foss. de l'Algér.* fasc. 8, p. 151, pl. xv.

Test rather large, cordiform in marginal outline, truncated and narrow behind, tumid dorsally, longer than broad, highest posteriorly, depressed, flat actinally.

Apical system subcentral, large, with four largely perforated basal plates, the madreporite separating the posterior basal plates, and the antero-lateral radial plates intercalated between the basal plates; the posterior radials in contact and separating the posterior basals.

Ambulacra narrow, subpetaloid, slightly open, in grooves, subequal, similar; poriferous zones abactinally, with large elongate outer and smaller comma-shaped inner pores, placed transversely; beyond the petaloid parts the pairs are small and close to the peristome, one pore is much smaller than the other of a pair.

Peristome excentric in front, subpentagonal, longest transversely, widely open, without a floscelle; with a posterior labrum. Periproct oval, supramarginal. Tuberculation scanty.

Fossil. Cretaceous: N. Africa.

The genus is evidently closely allied both to Cassidulids and Spatangoids, and should be placed near *Echinospatagus*.

Genus MEGALASTER, *Duncan*, 1877, *Quart. Journ. Geol. Soc.* xxxiii. p. 61.

Test large, elliptical in outline, with a deep anterior groove and small posterior truncation, depressed tumid abactinally, flat actinally.

Apical system excentric in front, small, with four genital pores.

Ambulacra diverse, the anterior in the broad deep groove

aborted more or less; the paired ambulacra with subequal petaloid parts, in deep, straight, or slightly flexuous grooves closed, the anterior pair more divergent than the posterior, not expanding but very equal in breadth.

Peristome very excentric in front and close to the notch, large, transverse, semilunar, and with a strong posterior labrum. Periproct large, elliptical, transverse, supramarginal, in the small truncation. Tuberculation very small. No fascioles.

Fossil. Miocene: Australia (see also Quart. Journ. Geol. Soc. 1887).

Genus HEMIPATAGUS, *Desor*, 1858, *Synopsis*, p. 416, pl. xliv. figs. 4–5. *Cotteau*, 1863, *Éch. foss. d. Pyrén.* p. 150.

Syn. *Tuberaster*, Peron & Gauthier.

Test small, cordiform, rather high, highest at the posterior truncation, as long as broad, tumid above, notched anteriorly, flattish actinally.

Apical system with four perforated basal plates; the madreporite central and extending posteriorly, and separating the postero-lateral basal plates.

Ambulacra diverse, the anterior with small pores, and the lateral petaloid, long, and comparatively flush, with sunken poriferous zones. Several large perforate and crenulate primary tubercles, in deep scrobicules, wide apart, in the lateral interradia abactinally.

Peristome semilunar, with a projecting posterior labrum; the amphisternum broad, smooth, and worn-looking. Periproct posterior, supramarginal. Fascioles absent.

Fossil. Eocene: Europe. Tertiary: Asia and Java. Pliocene: Europe.

Genus PLATYBRISSUS, *Grube*, 1865, *Jahresb. d. Schles. Ges. f. Vaterl. Cult.* p. 61. *A. Agassiz*, 1873, *Revision*, p. 562.

Test moderate, depressed, elliptical, and somewhat rounded in the thick ambital outline, tumid dorsally, flat actinally.

Apical system excentric in front, small, with four perforated basal plates, compact.

Ambulacra diverse, flush, the anterior with very few pairs of small pores; the lateral petaloid, but open at the ambitus, narrow;

the pores close, and the outer row the largest; the postero-lateral continued over the margin actinally as very broad areas, which nearly join and pass forwards on either side of a very linear sternum; the antero-lateral with some doubling of pairs near the peristome.

Ornamentation of the interradia of secondary tubercles and miliaries, largest near the ambitus, and actinally there are larger tubercles, which are more distant, and also miliaries.

Peristome large, semicircular, excentric in front, slightly sunken, with a feeble labrum, so that the margins are on the same level. Posterior interradium actinally with an ill-developed narrow sternum, which becomes a small triangular surface behind the close ambulacral areas. Periproct pointed, elliptical, marginal. Fascioles absent.

Recent. Position unknown.

The genus *Palæopneustes*, A. Agassiz, is one of the most interesting of the series described by its distinguished founder; it gave him much trouble, and he has pointed out how strange are its superficial and positive alliances with Cretaceous, Tertiary, and recent types. The difficulty of grasping the true meaning of the genus has, in consequence of the association of *Linopneustes* with it as a subgenus, been increased, and it appears really straining a point to classify so closely forms with and without well-developed marginal and subanal fascioles. It is proposed to raise *Linopneustes* (p. 258) to the position of a genus.

Genus PALÆOPNEUSTES, *A. Agassiz*, 1873, *Bull. Mus. Comp. Zoöl. Harv.* iii. no. 8, p. 188; 1874, *Hassler Exped. Ech.*, *Mem. Mus. Comp. Zoöl. Harv.* no. viii. p. 13; 1883, *Report on the 'Blake' Ech.*, *op. cit.* no. x. p. 60. (*Modified.*)

Test large, with a sharply defined or somewhat tumid ovoid ambitus, moderately high, subconical or subhemispherical abactinally, broadest anteriorly, broader than high; actinally flat, with a posterior oblique truncation.

Apical system slightly excentric in front, small, with four basal plates, three or all perforated, the right anterior containing part of the madreporite, which extends beyond, centrally, and separates the postero-lateral basal plates and also the posterior radial plates, and passes slightly into the posterior interradium.

Ambulacra diverse, flush, or nearly so, the anterior apetalous, with distant pairs of small round pores; paired ambulacra large, semipetaloid, open distally; outer pores of pairs elongate or comma-shaped, the inner round; beyond the petaloid portions, which are not very long, the pairs are continued as small round perforations in the large ambulacral plates to the peristome, where the plates become low and where fairly numerous pores are in peripodia; interporiferous areas with miliaries only, abactinally, with primary tubercles and miliaries actinally even over the postero-lateral ambulacra or not.

Interradia large, with primary tubercles scattered abactinally, and others, more or less numerous, on the plates remote from the sutures, crenulate and perforate, more numerous and crowded actinally.

Peristome excentric in front, large, semilunar, with a large projecting labrum; membrane plated. An amphisternum sloping on either side to the posterior ambulacra. Periproct supra-marginal, in the truncation, circular in outline, with numerous concentric plates. Spines variable, may be stout and long abactinally or small, always small actinally, and numerous and serrated, some spoon-shaped or broad at the top; within cellular. Abactinal tentacles branchial, those of the buccal region as pedicells with a globose top, and with long internal spicules. Fascioles absent, or a doubtful partial marginal.

Fossil. Eocene (?): Cuba.

Recent. Caribbean Sea.

The species described by Dames from the Eocene of the Vicentin is a *Plesiolampas*. See the similar ambulacra (p. 193).

M. Cotteau has described *Palæopneustes Antillarum*, 1875, from a probably Eocene formation in Cuba.

II. Division *Prymnadetes.*

The prymnadete Spatangoidea have not a true subanal fasciole enclosing a plastron, nor are the plates of the posterior ambulacra modified as in the Prymnodesmia; yet a linear fasciole may pass beneath the periproct from a lateral or marginal or peripetalous fasciole in some genera: one or more of the latter fascioles present.

Genus *Hemiaster.*

Subgenus *Tripylus.*

Genus *Faorina.*
Pericosmus.
Linthia.
Schizaster.
Prenaster.
Ornithaster.
Coraster.
Agassizia.
Moira.
Subgenus *Moiropsis.*
Genus *Hypsopatagus.*

The genus *Hemiaster*, Desor, has been greatly modified of late years, and some proposed new genera, which are characterized by peculiarities in the apical system alone, have been shown to be of no value (Ann. & Mag. Nat. Hist. ser. 6, 1888, vol. ii. p. 329). Desor took no notice of the apical system in his first definition, but unfortunately restricted the genus, subsequently, to the species which had an ethmophract system, the madreporite being in the right anterior basal plate. Lovén, A. Agassiz, and Gauthier have, however, explained the variability of the position of the madreporite and of the number of basal plates and genital pores. The classification adopted lately by M. Pomel, M. Munier-Chalmas, and by M. Cotteau is not consistent with the researches of zoologists.

The following is the first definition of the genus *Hemiaster* :—

Genus HEMIASTER, *Desor*, 1847, *Catal. Rais., Ann d. Sci. Nat.* sér. 3, vol. viii. p. 16, fig. in vol. vi. pl. 16. fig. 7.

Small swollen urchins; ambulacral summit posterior; ambulacra in broad shallow grooves, the posterior shorter than the anterior pairs. Peripetalous fasciole angular, encircling the ambulacral star; no subanal fasciole. Differs from *Micraster* in its more swollen shape and the fasciole.

Desor divided the genus :—1 type, Posterior ambulacra very short and barely half the length of the anterior petals. 2 type, Posterior ambulacra almost as long as the anterior, divergent, petals.

In Desor's Synopsis, 1858, p. 367, the following diagnosis occurs :—

" Small, squat, short tests, swollen above and at the sides, truncated behind, a shallow anterior groove; apical system compact,

with four genital pores. Ambulacra petaloid, limited, concave, divergent. Peristome strongly bilabiate. A peripetalous fasciole."

This somewhat imperfect diagnosis would contain the Mesozoic species and some recent forms; but it excludes certain species of Cretaceous, Tertiary, and Recent ages, if too great a value is placed upon the position of the madreporite, the number of genital pores, and the existence or not of a lateral fasciole, which may be more or less transient.

It is necessary to revise the genus, and to consider the evidence afforded by recent discoveries. It is now beyond doubt that some species of *Hemiaster* are viviparous, or rather that the female receives the young which have not been freely swimming Plutei into her ambulacral petals; that during growth the periproct is at first above a fasciole, which environs the petaloid parts of the ambulacra, and that as the opening becomes lower down and more posterior, it crosses and often divides the fasciole. Thus badly limited lateral and infra-anal fascioles occur or not. During growth the depth of the petals, the position of the madreporite, and the number of genital pores varies. (See A. Agassiz, Report on 'Challenger' Echini, p. 179.)

In 1845 Philippi, in Wiegm. Archiv, p. 344, pl. xi., diagnosed *Tripylus excavatus*, *T. cavernosus*, and *T. australis*, each with three genital pores only. He placed *Tripylus* as a subgenus of *Spatangus*. In 1851 Troschel, Wiegm. Archiv, p. 72, wrote on the "genus" *Tripylus*, and defined it as follows:—Test cordate, suborbicular, convex; ambulacra deep, the anterior pair subtransverse; the dorsal pole subcentral. Genital pores three. A fasciole including the ambulacra.

Troschel divided his genus into:—

1. *Hamaxitus*—a line of fasciole passing under the periproct. The type was *Tripylus* (*Hamaxitus*) *excavatus*, Philippi.

2. *Atrapus*—the infra-anal fasciole incomplete. *Tripylus grandis*, Trosch.

3. *Abatus*—no infra-anal fasciole. Species *Abatus cavernosus* and *A. australis*.

In 1851 Gray (Ann. & Mag. Nat. Hist. ser. 2, vol. vii. p. 132) diagnosed *Faorina*, and included *F. chinensis*, *F. antarctica*, and *F. cavernosa*. The last two species belong to the subgenus *Tripylus* of Philippi. He also noticed *Tripylus* to be a genus which included a new species, *Tripylus Philippi*.

Gray in 1855, Cat. Rec. Ech. Brit. Mus. p. 58, without noticing

Troschel, defined *Tripylus* as *Hemiaster* with the ambulacra surrounded by a very flexuous fasciole, with a lateral fasciole separating from it and descending under the vent; ovarial pores three or four. He remarked that the genus differs from *Desoria* (*Linthia*) and *Schizaster* in the regular cordate form and central vertex. He again admitted *Tripylus Philippi*, Gray, in the group, but unfortunately this species is a true *Schizaster*, and also *T. excavatus*.

In 1873 A. Agassiz, Revision, p. 588, placed *Tripylus* as a subgenus of *Hemiaster*, noticed the peripetalous fasciole with continuous lateral and anal fascioles; and in the specific description of *T. excavatus*, the only recognized species, he mentions the three huge genital openings. The deep ambulacra were necessarily remarked upon.

The same author, however, removed the species placed in *Faorina* by Gray and in *Abatus* by Troschel, namely "*cavernosus*" and "*australis*," back again into *Hemiaster*, and observed that he could not find a trace of the subanal fasciole figured by Philippi.

In 'Les Études,' Lovén, 1874, pp. 13, 16, pl. xi. fig. 99, a drawing is given of the apical system of *Abatus Philippi*, Lovén, 1871 (*non* Gray, sp.), Öfversigt af K. Vet.-Akad. Förh. no. 8, p. 1070; and two genital pores are prominent features, their basal plates being separated by a long madreporite. On pl. xxix. are plans of the test of *Abatus Philippi* and of the buccal and anal plates; and although it is evident that Lovén considers *Abatus* to be a genus, the only distinction between it and *Hemiaster*, given, refers to the two genital pores and the backward projecting madreporite.

A. Agassiz had the advantage of seeing Lovén's type, and as during the voyage of the 'Hassler' many other specimens were obtained, the results of their examination were published in 1874 (A. Agassiz, Zool. Results of the 'Hassler' Expedition, p. 20, pl. iv. figs. 4–8). It was shown that the number of genital pores is variable, "as we find two or three quite indifferently; the posterior pair of genital openings is always present; if a third exists it is the right anterior one usually, but sometimes the left." A. Agassiz terms this form *Hemiaster*, and gives *Abatus* as a synonym. He places *Tripylus cavernosus* as a *Hemiaster*, and only recognizes *Tripylus excavatus*, Phil.

Mr. Edgar A. Smith (1879, Phil. Trans. Roy. Soc. clxviii. p. 271) placed under *Hemiaster* the *Abatus cavernosus*, and its synonyms (generic) *Brissus*, *Tripylus*, *Faorina*.

In the Report on the 'Challenger' Echini, 1881, p. 182, A. Agassiz united the species *Tripylus cavernosus* and *T. australis*, and absorbed them and *Abatus Philippi*, Lovén, in the genus *Hemiaster*; he noticed that in a full-grown specimen of the species "*cavernosus*" he could not find an anal fasciole. That was in accordance with Troschel, but in young specimens distinct anal fascioles joined to lateral ones existed, whilst in still larger tests the lateral fasciole had disappeared, the linear subanal remaining (p. 177).

The sex has much to do with the variation in structure of the apical system, and the number of pores is two or three; the female which was drawn (pl. xx *a*. fig. 19) had two genital pores only, the males have three.

In 'Pourtalesia,' 1883, p. 72, Lovén holds his ground with regard to the generic value of *Abatus*, and attributes it to Troschel. Certainly *Abatus* was a section of *Tripylus* according to Troschel. Lovén gives the synonymy of the species "*cavernosus*" and "*australis*," and it is interesting to observe that he is alone in the employment of the term *Abatus*. But although there may be a difference of opinion regarding the classification employed by the illustrious Professor, everybody must admire and be thankful for the anatomy given by him of the young "*cavernosus*," whatever its correct generic name may be, in which he indicates a fifth basal plate placed between the posterior radial plates and bearing the madreporite. Moreover, he has shown how homogeneous a group the ethmophract species of *Hemiaster* are, and that to introduce the others within the same category would violate the simplicity of the genus as established by Desor. But it must be conceded that Lovén's teaching infers evolution of the ethmolysian from the ethmophract "calyx," and if the modern species of *Hemiaster* of the first group are the descendants of the ancient ethmophracts, surely it is a reason for preserving the genus with necessary modifications.

After what has been written, it appears necessary to absorb *Abatus* in *Tripylus* as a subgenus of *Hemiaster*. The attempt to divide the genus *Hemiaster* by grouping the species with four basal plates, each perforated, and having the madreporite separating the postero-lateral basals, under the genus *Trachyaster*, Pomel, will fail amongst the students of the recent fauna. The distinction is specific, and the so-called genus lapses. *Ditremaster* of M. Munier-Chalmas (1885, Compt. Rend. Acad. Sci. 2 semestre,

p. 1076), quoted by M. Cotteau in Pal. Franç. (1887, Terr. Eocène, p. 411), is the same thing as *Abatus*, sensu Lovén, and is synonymous with *Tripylus* (see Duncan & Sladen, 1888, Ann. & Mag. Nat. Hist. ii. p. 333). The history of the species "*cavernosus*" should have been studied by the distinguished French Echinodermatists. *Ditremaster* is of no classificatory value. It appears to be reasonable, under the circumstances, to add to and alter slightly the Desorian diagnosis of *Hemiaster*, and to divide the genus into two types in reference to the position of the madreporite, the number of genital pores depending much upon the position of that upper end of the water-system. Finally *Tripylus*, with its persistent or evanescent latero-anal fasciole, may remain as a subgenus which will include *Abatus*, and it will come within the second division of the genus. I have found that Mr. Bone, who was Dr. Wright's artist, was correct in drawing a peripetalous fasciole in *Epiaster De Loriolii*, Wright. The species was placed in *Hemiaster* by Dr. S. P. Woodward; and therefore there is a large *Micraster*-like *Hemiaster* in the Upper Greensand with a delicate peripetalous fasciole, and this is the sole distinction from *Epiaster*.

Genus Hemiaster, *Desor*, 1847, *Cat. Rais.*, *Ann. d. Sci. Nat.* vol. viii. p. 16; 1858, *Synopsis*, p. 367. *A. Agassiz*, 1872–74, *Revision*, p. 585; *'Hassler' Echini*, p. 20; 1881, *'Challenger' Echini*, p. 177, pl. xx *a*. *E. A. Smith*, 1879, *Phil. Trans. Royal Soc.* vol. clxviii. p. 271. *Lovén*, *Études*, 1874, pls. xi. & xxix.; 1883, *Pourtalesia*, p. 72. *Gauthier*, 1887, *Assoc. Franç. Sci.* p. 406. *Duncan & Sladen*, 1888, *Ann. & Mag. Nat. Hist.* ser. 6, vol. ii. p. 329. *De Loriol*, 1888, *Faune Crét. du Portug.*, *Éch.* vol. ii. fasc. 2, p. 98.

Syn. *Trachyaster*, Pomel; *Abatus* (sensu Lovén); *Leucaster*, Gauthier, 1887; *Perionaster*, Gauthier, 1887; *Ditremaster*, Munier-Chalmas, 1885; *Opissaster*, Pomel (pars).

Test moderate and rarely large, cordiform in tumid marginal outline, with a more or less well-defined anterior groove, narrowest and truncated posteriorly, undulating or gibbose at the sides, short or longer than broad, highest subcentrally or posteriorly to the true centre, varying in height, tumid in the interradia dorsally, often keeled posteriorly to the vertex. Actinal surface swollen behind the peristome.

Apical system subcentral, with two to four basal plates, rarely

a fifth basal, two, three, or all perforated by ducts; the madreporite in the right anterior basal or extending centrally and more or less posteriorly, separating the postero-lateral basal plates and sometimes the posterior radial plates also.

Ambulacra diverse, the anterior in the groove; the pores oblique, in pairs on either side, plates numerous and low; antero-lateral ambulacra petaloid dorsally, sunken, more or less tending to close, diverging; the postero-lateral ambulacra with shorter petals than the antero-lateral or subequal, not so divergent; the pores of the petaloid parts of both of the ambulacra subequal, sometimes diverse, usually in narrow grooves, the outer pores usually the larger, elongate; actinally the posterior ambulacra are broad on either side of the tumid sternum, the pores beyond the petals distant but in pairs.

Interradia narrow at the apex and also at the peristome, with but few plates, many tumid; a small labrum anterior to an amphisternum; the episternum not developed; the plates below the periproct subequal. Normal heteronomy of right posterior interradium by union of the second and third plates of zone *a*.

Peristome excentric in front, transverse, open, semi-lunar, with a posterior labrum and often with raised antero-lateral edges. Periproct ovoid or elliptical, long vertically, high in the posterior truncation. Ornamentation small, a few primary tubercles perforate and crenulate, closest and largest actinally near the margin and on the sternum; miliaries abundant.

A peripetalous fasciole encircling the petaloid parts of the ambulacra, crossing the anterior groove and the keel behind the vertex, angular or subcircular, variable in its entry between the petals. Large disciferous tentacles within the fasciole on the anterior ambulacrum, others more or less branchial on the petals. Spines small, largest actinally and at the edges of the petals, which they may cover over. Depth of ambulacral petals variable according to age and sex, used as marsupia in the females.

Type I. *Ethmophracti.*—With four perforated basal plates, the madreporite in the right anterior basal plate and not separating the other basal plates.

Type II. *Ethmolysii.*—Two or three, rarely four, basal plates with genital ducts; the madreporite passing centrally and posteriorly, separating the postero-lateral basal plates and in some the posterior radial plates also.

Leucaster, Gauthier, 1887, Bull. Soc. d. Sci. Hist. et Nat. de l'Yonne, vol. 41 *e* (pub. 1888), p. 386, is a *Hemiaster* with very small pores in the anterior zone of the antero-lateral ambulacra near the apex.

Perionaster, Gauthier, 1887, *ibid.* p. 389. The type is a very small immature *Hemiaster*, with a remarkably developed peripetalous fasciole, see *H. expergitus*, Lovén.

Type I.—*Fossil.* Cretaceous: England, Europe, N. Africa, Arabia, Hindostan, N. and S.; N. America?

Recent. E. Atlantic; W. of Spain; Caribbean Is., 464–485 fms.; Bahia; Canaries, 620–750 fms.; Japan; Arafura Sea, 345–800 fms.

Type II.—*Fossil.* Tertiary: England, Europe, W. Indies, N. Africa, Egypt, Asia, Sind; Australia?; Java, N. America.

Recent. S. Hemisphere, Patagonia, Chili, Magellan, La Plata coast, Kerguelen, Heard Is., Staten Land, South Polar Seas.

Subgenus TRIPYLUS, *Philippi*, 1845; *Troschel*, 1851 (genus), division Hamaxitus, *Wiegm. Arch.* 1851, p. 72.

Syn. *Abatus*, Troschel.

Hemiasters with two genital pores in the female and three in the male, the apical system Ethmolysian, may have a fifth basal; peripetalous fasciole (around petaloid ambulacra deeply sunken in the female); a slender latero-anal fasciole, which may be incomplete. Type *T. excavatus*, Phil.

Recent: Patagonia and Chili.

Genus FAORINA, *Gray*, 1851, *Ann. & Mag. Nat. Hist.* vol. vii. p. 132; 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 56 (pars). *A. Agassiz*, 1872–74, *Revision*, pp. 129, 607. *Lovén*, 1874, *Études*, pl. xxvii.

Test moderate in size, broadly cordiform in outline, grooved in front, narrower and truncated posteriorly, high and subconical. The vertex is central.

Apical system excentric in front, with four basal plates, two of which, or sometimes three, are perforated; madreporite projecting backwards.

Ambulacra dissimilar, the anterior in the groove with minute pairs of pores abactinally, and larger and more distinct actinally; the antero-lateral straight, sunken, divergent, open distally, the pairs of pores indistinct near the apex and elsewhere large and

regular; the zones are nearly parallel; interporiferous area smaller than the poriferous zones; the postero-lateral straight, sunken, open, shorter where petaloid than the antero-lateral and not so divergent, pores as in the other pair.

Peristome excentric in front, slightly semilunar, but narrow from before backwards and generally small; a broad posterior labrum. A narrow amphisternum, bounded by broad ambulacral areas. The convex actinal surface with small interradial plates, the right posterior interradium with abnormal (or ancient) heteronomy, the second plates of zones *a* and *b* uniting. Periproct elliptical at the upper part of the posterior truncation.

A peripetalous fasciole following the general outline of the test, and the anterior part of it double and with or without offshoots. A very slender linear infra-anal fasciole extending from below the periproct to the ambitus near the ambulacra. Horizontal sutures often bare. Ambulacra bare on either side of a tuberculate sternum; tubercles uniform from the ambitus to the peripetalous fasciole, larger above it and adjoining the petals.

Recent. China. One species, *F. chinensis*, Gray.

The subanal branch is not sufficient to modify the posterior ambulacral plates, and does not bound a plastron.

Genus Pericosmus, *Agassiz*, 1847 (subgenus), *Catal. Rais., Ann. d. Sci. Nat.* sér. 3, vol. viii. p. 19. *Herklots*, 1854, *Java Ech.* pt. 4, p. 16. *Desor*, 1858, *Synopsis*, p. 396. *McCoy*, 1882, *Prodr. Pal. Vict.* dec. vii. pp. 15–21, pls. 64–68. *Duncan*, 1887, *Quart. Journ. Geol. Soc.* vol. xliii. p. 423.

Test moderate to very large in size, thick, subcordiform, elongate or short, tumid and depressed dorsally, with a well-marked anterior groove, and more or less truncated posteriorly.

Apical system subcentral, compact and small; number of genital pores variable.

Ambulacra diverse, the anterior in the groove with small pairs of pores; the antero-lateral divergent, long, sunken, the posterior shorter and closer, pores unequal.

Periproct large, excentric in front, labiate. Periproct oval, upon the posterior surface. Ornamentation small.

A peripetalous fasciole circumscribing the petaloid parts of the ambulacra, and a marginal fasciole passing all round the test, sometimes slightly disconnected.

Fossil. Upper Cretaceous (?). Eocene: Europe, N. Africa Java. Miocene: Australia.

M. Cotteau, Éch. Foss. de l'Algérie, 1885, fasc. 9, p. 68, mentions that M. Pomel considers that *P. Nicaisei*, Pom., has an apical system like *Micraster*, but that he finds three genital pores. He states that the greater number of species have only two genital pores. This is but one of the many proofs that the number of genital pores in a species is not a guide to its generic position.

Agassiz regarded *Pericosmus* as his third division of *Hemiaster*.

Genus Linthia, *Merian*, 1853, *Note sur les Éch.*, *Actes Soc. Helv.* p. 278. *Desor*, 1853, *Synopsis*, p. 395. *A. Agassiz*, 1872–74, *Revision*, pp. 138, 604; 1881, *Report on 'Challenger' Ech.* pp. 199, 204. *Lovén*, 1874, *Études*, pl. xxviii. *E. A. Smith*, 1878, *Ann. Mag. Nat. Hist.* ser. 5, vol. i. p. 67. *Cotteau*, 1887, *Bull. Soc. Zool. France*, vol. xii. p. 556.

Syn. *Desoria*, Gray, 1851; *Periaster*, d'Orb., 1854.

Test variable, small to large, oval or cordiform, grooved anteriorly, subacuminate or truncated posteriorly, tumid and gibbose dorsally, almost flat actinally.

Apical system small, excentric in front; four perforated basal plates; the madreporite separating the posterior basal plates and also the posterior radial plates.

Ambulacra diverse; the anterior in the broad groove, the pores round and small; the antero-lateral long, with the petaloid parts in grooves, moderately long, divergent, pairs of pores equal or subequal, nearly closing distally; postero-lateral ambulacral petals also in sunken grooves, less divergent and shorter than the others. Ambulacra forming the greater part of the peristomial margins, and moderately broad on either side of the sternum.

Peristome excentric in front, semilunar, with a well-developed posterior labrum. An amphisternum; the second plates of both of the zones of the right posterior ambulacrum united, so as to produce ancient heteronomy. Periproct at the upper part of the posterior truncation.

A peripetalous fasciole entering the interradia, a lateral fasciole starting from the peripetalous close to the antero-lateral ambulacra and passing beneath the periproct. Tubercles crowded, largest actinally, usually crenulate and perforate, and either on flat or in sunken scrobicules.

Fossil. Cretaceous: Europe, Africa, N. America. Tertiary: Europe, Africa, W. Sind, W. Indies.

The S. Hindostan Cretaceous species are now placed under *Hemiaster* by Stoliczka. *Periaster*, d'Orb., covers the same ground as *Linthia*; but see A. Agass., 1883, Report on 'Blake' Echini, p. 77.

Recent, as *Desoria*, Gray, 1851 & 1854, Cat. Rec. Ech. Brit. Mus. p. 58; and *Periaster*, A. Agass. sp., 1883, 'Blake' Echini, p. 77:—Australia, Tasmania, Pacific Islands (?); Arafura Sea, W. Indies.

Genus SCHIZASTER, *Agassiz*, 1847, *Catal. Rais.*, *Ann. d. Sci. Nat.* vol. viii. sér. 3, p. 20. *Desor*, 1858, *Synopsis*, p. 389. *A. Agassiz*, 1872–4, *Revision*, pp. 363, 609; 1881, *Report on 'Challenger' Ech.* p. 199; 1883, *'Blake' Ech.* p. 74. *Lovén*, 1874, *Études*, pl. xxxi.

Syn. *Opissaster*, Pomel (pars); *Periaster*, sensu A. Agass.

Test thin, small to large, tall to depressed, cordiform in tumid marginal outline, sloping up to the posteriorly excentric apical system; highest behind and truncated or acuminate posteriorly, may project there, slightly tumid actinally, with a broad and deep anterior groove, which marks the dorsum.

The apical system moderate in size, with two, three, or four basal plates perforated, and the madreporite extending centrally and posteriorly, and separating the posterior basal and radial plates.

Ambulacra diverse, the anterior in the groove and with close oblique pores in pairs, either in a single row on either side or confused and crowded: paired ambulacra petaloid, much sunken; the anterior flexuous, longest, only slightly divergent and extending forwards; the posterior smaller and closer, often very small; the poriferous zones broad and closing distally. The ambulacral areas on either side of the long sternum are narrow. The interradia are more or less gibbose and broad, and the second and third plates of zone *a* of the right posterior area are fused actinally.

Peristome excentric in front, semilunar, with a projecting posterior labrum and a large amphisternum. Periproct in the posterior truncation.

Ornamentation close and homogeneous, largest actinally and anteriorly. Spines short, slightly curved abactinally, and club-shaped at the end, larger and longer actinally, a tuft over the anal system, and two lateral tufts, rather close, at the end of

the actinal plastron. Fascioles: a peripetalous, and usually a lateral, which diverges from the former near the ends of the antero-lateral petals and passes beneath the periproct.

Fossil. Tertiary: England, Europe, India, Australia, West Indies, N. America, N. Africa.

Recent. N.E. Atlantic coast, Florida, West Indies, S. America, Cape of Good Hope, Mediterranean, Red Sea, Indian Islands, Japan, Philippines, China, Arafura Sea, Fiji, Marion and Kerguelen Islands (37–1507 fms.).

The synonymy of this genus is given by A. Agassiz in his 'Revision.' Unfortunately *S. gibberulus* has been placed in *Agassizia* by M. Cotteau, and subsequently in *Anisaster*, Pomel. Apparently the genus *Paraster*, Pomel, is a synonym.

Genus PRENASTER, *Desor*, 1853, *Note sur les Éch.*, *Act. de la Soc. Helv. d. Sci. Nat.* p. 279; 1858, *Synopsis*, p. 401. *Duncan & Sladen*, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pt. ii. p. 90, pl. xix.

Test small or moderate in size, ovoid in marginal outline, rounded in front and truncated posteriorly, tumid and depressed dorsally, but rather boldly arched, convex behind the peristome actinally. There is no anterior groove.

Apical system very excentric in front, small, with four perforated basal plates, and the madreporite passing backwards and separating the posterior basal and radial plates.

Ambulacra diverse, the anterior flush, with pairs of small oblique pores; the paired ambulacra in very faint grooves, not closing, subpetaloid, almost straight; the anterior the longest and very divergent; some slight difference may exist between the dimensions of the anterior and posterior rows of pairs of pores in the antero-lateral ambulacra.

Peristome excentric in front, with a strong labrum. Periproct at the top of the posterior truncation.

Tubercles small to moderate, scrobiculate, perforate and crenulate, largest actinally.

A peripetalous fasciole wanting anteriorly, not extending beyond the point of junction with the marginal fasciole. A marginal fasciole surrounding the test, dipping down in front, and passing below the periproct behind.

Fossil. Eocene: Europe, Asia (W. Sind), N. Africa.

Genus ORNITHASTER, *Cotteau*, 1886, *Éch. nouv. ou peu connus*, *Bull. Soc. Zool. de France*, vol. xi. p. 710.

Test moderate in size, thick, slightly elongate, tumid above, broadest and rounded in front, subtruncated behind, highest near the posterior surface, broader than high. No anterior groove.

Apical system excentric in front, subcompact, with four close genital pores.

Ambulacra dissimilar, all flush, narrow, and enlarging slightly to the ambitus; the anterior without a groove, with simple pairs of pores arranged more or less obliquely. The paired ambulacra slightly subpetaloid, open; the inner pores circular and the outer comma-shaped; pairs close abactinally and distant at the ambitus. Interradial ornamentation of numerous small scrobiculate tubercles most frequent actinally and much granulation.

Peristome rather large, subcircular, superficial, slightly excentric in front, without a trace of labrum or phyllodes. Periproct circular, at the summit of the posterior truncation.

A peripetalous fasciole well developed, not sinuous, approaching the periproct, but anteriorly and superiorly, and crossing the ambulacra above the ambitus and sloping in front so as to be at a much lower level there than posteriorly.

Fossil. Eocene: Europe (Spain).

M. Cotteau places the genus near *Coraster*, Cotteau.

Genus CORASTER, *Cotteau*, 1886, *Bull. Soc. Zool. de France*, vol. xi. p. 708. *Seunes*, 1888, *Bull. Soc. Géol. de France*, sér. 3, vol. xvi. p. 801.

Test small, thick, circular in marginal outline, subtruncated posteriorly, regularly tumid and high dorsally. A very small anterior furrow.

Apical system subcompact, with four basal plates and each with a pore, and the madreporite not separating the postero-lateral plates.

Ambulacra dissimilar, flush, straight, narrow, enlarging with approach to the ambitus; the anterior with minute distant pairs of pores; the paired ambulacra with the inner row of pores circular, and the outer comma-shaped and oblique.

Tubercles abundant, small, scrobiculate, and with homogeneous miliaries.

Peristome very excentric in front, slightly sunken, subcircular, and with a posterior labrum which projects. Periproct circular, at the top of the posterior truncation.

Fasciole peripetalous, well developed, subcircular, sloping downwards and forwards, cutting across the ambulacra far above the ambitus, nearly circular but slightly angular in the postero-lateral interradia. Pores below the fasciole circular and similar.

Fossil. Upper Cretaceous or Eocene: Europe (Spain, France); Asia (Turkestan).

Genus AGASSIZIA, Valenciennes, 1846, *Voy. d. Venus,* pl. i. fig. 2. *Agassiz*, 1847, *Ann. d. Sci. Nat.* vol. viii. p. 20. *Lütken*, 1863 (pub. 1864), *Vid. Medd. f. Nat. For. i Kjöb.* p. 134. *A. Agassiz*, 1872–4, *Revision*, pp. 88, 353, 594; 1883, '*Blake*' *Ech.* p. 71, pl. 25. *Lovén*, 1874, *Études*, pl. xxx. figs. 191–193; 1883, *Pourtalesia*, pl. x. fig. 93.

Test thin, ovoid, moderate in size, truncated posteriorly, tumid and subhemispherical dorsally, highest posteriorly, without an anterior groove, rather flat actinally, with a convex surface behind the peristome.

Apical system excentric or subcentral posteriorly, or not; small, with four close perforated basal plates. Madreporite in the right anterior basal.

Ambulacra diverse, the anterior in a very narrow depression; the pairs of pores small and distant, the tentacles with a sucker and penicillate; the antero-lateral ambulacra divergent, long, open, slightly curved, with the anterior row of pairs of pores absent; postero-lateral shorter than the antero-lateral, closer, and with both rows of pairs of pores developed. Plates 2 and 3 of zone *a* of the right posterior interradium fused.

Peristome very excentric in front, narrow, transverse, with a posterior labrum and a well-developed amphisternum; peristomial plates rather large near the anterior margin. Periproct elliptical, transverse, in the posterior truncation, its plates large near the edge.

A peripetalous fasciole entering the angles of the interradia, especially posteriorly. A lateral fasciole arising from the peripetalous close to the distal ends of the antero-lateral ambulacra and passing backwards to reach the posterior surface of the test below the periproct. The anterior part of the peripetalous fasciole dips down so as to be visible from the actinal surface.

Spines delicate, and those of the miliaries club-shaped. Ambulacral pedicellariæ small-headed, long-stemmed, articulated at the base. Tentacles, some of the anterior near the apical system

fimbriated like the buccal, others disciferous; within the petals the tentacles are broad, compressed, lobed, beyond simple; buccal tentacles pedicellate. Anal plates large, often less than eight, and projecting.

Fossil. Tertiary: N. America, West Indies.

Recent. Florida, Gulf-stream, Caribbean Islands, Peru, Panama, Gulf of California, 36–391 fms.

Agassizia gibberula, Cott., is a *lapsus calami*, it is a *Schizaster*.

Genus MOIRA, *A. Agassiz*, 1872, *Revision of the Echini*, p. 365.

Syn. *Mocra*, Michelin, 1855; Lütken, 1863 (pub. 1864), Vid. Medd. f. Nat. For. i Kjöb. p. 123.

Test moderately high, thin, tumid abactinally and rounded from side to side actinally.

Apical system subcentral, with two of the basals perforated for genital ducts.

Ambulacra resemble narrow and deep slits starting from the summit; the anterior notches the front of the test and the groove is continued to the peristome. Coronal plates tumid, except near the sutures.

Peristome excentric in front, semilunar, and with a projecting posterior lip. Periproct on the truncated posterior surface.

A peripetalous fasciole clings to the very edges of the deep ambulacral grooves. A latero-anal fasciole. Tubercles small. The anterior ambulacrum is sometimes divided, and all the ambulacra form broad projections on the inside of the test.

Fossil. Miocene: Sind. Post-Pliocene: S. Carolina.

Recent. Red Sea, Zanzibar, West Indies to N. Carolina, California, 60 fms.

Subgenus MOIROPSIS, *A. Agassiz*, *Report 'Challenger' Echin.* p. 205, pl. xxxvi. figs. 4–7 (1881).

Test high, cordate, the high incurved posterior surface extending inferiorly into a backward, prominent and well-developed beak.

Anterior ambulacrum shorter than the antero-lateral and longer than the very short posterior ambulacra; all are petaloid. The anterior ambulacrum is the broadest and the postero-lateral are very small. The anterior ambulacrum has a petaloid end which is in the shallow anterior groove.

The peripetalous fasciole is small, and the latero-anal is well developed and passes from the peripetalous fasciole, about halfway down the antero-lateral petal, and crosses the side of the test

obliquely so as to pass over the posterior face at some distance below the top of the test and the periproct.

Recent. Indian Archipelago, 129 fms.

The subgeneric character is the shape and relative size of the anterior ambulacrum.

Genus HYPSOPATAGUS, *Pomel*, 1883, *Thèses*, p. 31. (*Slightly enlarged.*)

Syn. *Macropneustes*, Agass. (pars).

Test moderate and large, tumid in ovoid outline, depressed and tumid dorsally, rostrated posteriorly and truncated.

Apical system subcentral, or slightly excentric in front.

Anterior ambulacrum in a slight groove; pores simple. Paired ambulacra either long and grooved, or shorter and broad and semi-flush; the poriferous zones slightly sunken, and the interporiferous areas ornamented and tumid.

Peristome excentric in front, semilunar, transverse. Periproct in the posterior truncation. A peripetalous fasciole including scarce or moderately close primary tubercles.

Fossil. Eocene: Europe and Africa and Asia. Miocene: N. Africa.

M. Pomel cites as the types *H. Meneghinii* and *H. Ammon*, and the Sindian species of *Macropneustes* become *Hypsopatagus speciosus*, Dunc. & Sladen, *H. rotundus*, Dunc. & Sladen.

III. Division *Prymnodesmia.*

Spatangoidea with a subanal fasciole, and the plates of the postero-lateral ambulacra within the fasciole modified, and their pores also. Other fascioles may exist.

Genus *Micraster.*
Subgenus *Brissopneustes.*
Genus *Brissus.*
Subgenus *Meoma.*
Genus *Spatangomorpha.*
Troschelia.
Metalia.
Rhinobrissus.
Brissopsis.
Subgenus *Cyclaster,*
Genus *Brissopatagus.*
Spatangus.
Subgenus *Loncophorus.*

Genus *Maretia.*
Eupatagus.
Subgenus *Macropneustes.*
Genus *Nacospatangus.*
Gualtieria.
Linopneustes.
Neopneustes.
Cionobrissus.
Echinocardium.
Breynia.
Lovenia.

Genus MICRASTER, *Agassiz*, 1840, *Cat. Syst.* p. 2; 1847, *Cat. Rais.*, *Ann. d. Sci. Nat.* sér. 3, vol. viii. p. 23. *Desor*, *Synopsis*, 1858, p. 360. *Lovén*, 1874, *Études*, pls. xi., xxxiii. *Duncan & Sladen*, 1884, *Foss. Ech. W. Sind*, pt. iii. p. 189, pl. xxxvii. (*Pal. Ind.* ser. xiv.). *Gauthier*, 1887, *Bull. Soc. d. Sci. Hist. et Nat. de l'Yonne*, vol. 41 *e* (pub. 1888), p. 367.

Test moderate or large, cordiform, narrowest and truncated posteriorly, tumid, rather depressed.

Apical system excentric in front, small, with four perforated basal plates, rarely with only three perforations; the madreporite either restricted to the right anterior basal, or passing beyond it and separating the postero-lateral basal plates. (The Tertiary species have only three genital perforations.)

Ambulacra diverse, sunken; the anterior apetaloid, with the small pairs of pores becoming distant towards the ambitus; the antero-lateral ambulacra subpetaloid dorsally, diverging, longer in the subpetaloid part than the postero-lateral; postero-lateral ambulacra forming a slight angle at the apex; pores of both areas elongate.

Interradia with large plates; actinally the right postero-lateral area has the second and third plates of zone *a* coalesced, the corresponding plates of the left postero-lateral (4) interradium being separate. A symmetrical amphisternum, but without an episternum; many plates between the sternum and the periproct, which is oval and high up in the truncated or grooved posterior face, and sometimes overhung by the end of the keel of the posterior interradium. Subanal fasciole broad; the sixth ambulacral plate and four others being altered in shape, and each having a pair of pores within the fasciole.

Peristome excentric in front, transversely elliptical, with a small posterior projecting labrum.

Ornamentation of very small raised perforate and crenulate tubercles abactinally, with numerous small granules which are very marked in the anterior groove; tubercles larger, sunken and surrounded by granules actinally, and crowded in lines on the post-oral region.

Fossil. Cretaceous: England, Europe, Africa, S. Hindostan. Eocene: Asia (Sind). Miocene: Australia.

Lovén has pointed out that the episternum is not developed in this genus, which is nevertheless amphisternous, the arrangement foreshadowing that of the later Spatangoids. The forms included in the genus have an Ethmophract apical system, the fifth basal plate being absent, and the madreporite sometimes slightly separates the postero-lateral basals. There are some plates of the bivium between the petaloid part and the subanal fasciole which are uniporous; but all the plates of the trivium are biporous. The petaloid arrangement is rather imperfect, the distal ends not absolutely closing; usually the grooves between the plates of the ambulacra, except the anterior, are very distinct.

Subgenus BRISSOPNEUSTES, *Cotteau*, 1886 (genus), *Bull. Soc. Zool. de France*, vol. xi. p. 712, pl. xxiii. figs. 9–12.

Test small, oval, ovoid, elongate, narrowest and truncated posteriorly, tumid dorsally and slightly actinally.

Apical system excentric in front, small; four basal plates in contact and three are perforated. The madreporite in the right anterior imperforate basal plate. The anterior poriferous zone of the antero-lateral ambulacra smaller than the posterior zone.

Fossil. Eocene: Europe.

In dealing with the affinities of this somewhat doubtful genus, M. Cotteau compared it with *Isopneustes*, Pomel, 1883, Thèses, p. 43, a genus (?) which was defined in relation to *Micraster*, and has "pas de fasciole péripétale, ni probablement de sous-anal."

M. Seunes, 1888, Bull. Soc. Géol. de France, vol. xvi. p. 793, states that there is a partial peripetalous fasciole in *Isopneustes*, and hence the genus has not been sufficiently diagnosed.

Genus BRISSUS, Klein, 1734, *Nat. Disp. Ech.* p. 36. *Gray*, 1825, *Ann. Phil.* p. 9. *Agassiz & Desor*, 1847, *Cat. Rais.*, *Ann. d.*

Sci. Nat. sér. 3, vol. viii. p. 12. *Desor*, 1858, *Synopsis*, p. 403. *A. Agassiz*, 1872, *Revision*, pp. 96, 356, 596. *Bolau*, 1872, *Spatang. d. Hamb. Mus.* p. 14. *Lovén*, 1874, *Etudes*, figs. 43, 122, 123, 202–204. (*Amended.*)

Syn. *Brissomorpha*, Laube; *Heterobrissus*, Manz. & Mazz.

Test moderate and large, ovoid in tumid marginal outline and narrowest posteriorly, regularly convex but depressed dorsally, tumid and convex actinally, except in front of the peristome, truncated obliquely downwards and forwards at the posterior surface below the ambitus, or straight; no anterior groove beyond some slight local depression.

Apical system excentric in front, the four basal plates perforated, and the madreporite extending from the right anterior basal, centrally, and thence posteriorly so as to separate the postero-lateral basal and radial plates.

Ambulacra diverse, the anterior flush or in a very slight depression; the pairs of pores small and closest abactinally; antero-lateral ambulacra very divergent, nearly forming a straight transverse line, in grooves of varying depth, the petaloid parts shorter than the corresponding parts of the postero-lateral ambulacra, which are comparatively close together; the pores of the inner rows of a round or slightly elongate shape, and those of the outer rows elongate; petals with narrow interporiferous areas and the pairs tending to close, the distal ends of the postero-lateral petals diverging outwards or not. Actinally the postero-lateral ambulacra are very narrow and long, with few single pores, more numerous at the peristome.

Interradia large actinally, with very large second and third plates; normal heteronomy of interradium I.

Peristome excentric in front, semilunar, with a large projecting posterior labrum, behind which is a broad amphisternum; sphæridia numerous. Periproct in the posterior truncation, large.

A peripetalous fasciole entering the lateral interradia considerably, sinuous more or less; a subanal fasciole surrounding a broad area including six ambulacral plates, the upper part of the fasciole concave. Ornamentation of very crowded almost homogeneous tubercles abactinally, and of slightly larger tubercles actinally; rarely some larger tubercles within the peripetalous fasciole. Spines slender, moderately long on the anterior part of the test; dark brown, yellow, to silver grey.

Fossil. Crag: England. Eocene, Miocene, Pliocene: Europe. Miocene: Asia (Sind and Madura). Tertiary: N. America, West Indies.

Recent. Arctic Seas, N. Atlantic to Azores, Mediterranean, West Indies and Brazil, Pacific, W. coast of America. 7–450 fms.

This definition covers the recent forms and most of the Tertiary species, but Wright's *B. tuberculatus* has necessitated the addition regarding the occasional presence of larger tubercles within the peripetalous fasciole, as in *Metalia*.

The genus *Brissomorpha*, Laube, 1871, is similar to *Brissus*; and the genus *Heterobrissus*, Manzoni and Mazzetti, 1877, is unsatisfactory on account of the indifferent state of preservation of the specimens of the sole species; it may be a *Brissus*.

Brissus depressus, a form which has never been obtained in a condition of preservation worthy of description, has been made the type of a new genus, *Leiopneustes*, by M. Cotteau, 1885, Pal. Franç., Terr. Crét. p. 123. Considering that it is written "fascioles absent or very slightly apparent," the value of the genus is problematical.

Subgenus MEOMA, *Gray*, 1851 (genus), *Ann. & Mag. Nat. Hist.* vol. vii. p. 132; 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 56. *Lütken*, 1863 (pub. 1864), *Vid. Medd. f. Nat. For. i Kjöb.* p. 120. *A. Agassiz*, *Revision*, 1872–74 (subgenus), pp. 358, 603. *Lovén*, 1874, *Études*, pl. 35.

Test moderately stout, cordiform, the paired ambulacra sunken in deep grooves, antero-lateral divergent.

Peripetalous fasciole slender, flexuous, entering the interradia between the petals. A subanal fasciole slender and incomplete above, a slender offshoot passing abactinally on either side of the periproct.

Fossil. Tertiary: Cuba. Miocene: W. Sind. The genus is not represented in the Australian Tertiaries.

Recent. Gulf of California, Acapulco, West-Indian Islands, Gulf of Florida. 242 fms.

Genus SPATANGOMORPHA, *Böhm*, 1882, *Densksch. d. kais. Akad. Wiss. Wien*, Bd. xlv. p. 367.

Test moderate, elongate oval, depressed, notched anteriorly, highest and truncated posteriorly, depending below the periproct.

Anterior ambulacrum in a shallow groove; the paired ambulacra shallow, lanceolate, moderately long; pores somewhat diminished near the apex. Odd interradium separated, actinally, from the labrum by the junction of the broad posterior ambulacral areas.

Peristome excentric in front, semilunar; sternum nipped in greatly posteriorly. Periproct high up in the posterior truncation.

A large subanal fasciole, with at least eight pairs of ambulacral plates and pores included. Large sunken primary tubercles and granules, the former absent in the posterior interradium. A peripetalous fasciole limiting and bounding the tubercular areas.

Fossil. Tertiary: Madura, Java.

The genus is remarkable on account of the unusual number of ambulacral plates implicated in the subanal fasciole and for the junction of the ambulacra actinally, so as to separate the sternum from the peristome.

Genus TROSCHELIA, *Duncan & Sladen*, 1883, *Pal. Ind.* ser. xiv., *Monogr. Tert. Echin. Kachh and Kattywar*, p. 67, pl. vii. figs. 9–12, and pl. xi. fig. 5.

Test rather large, long, oval, high, notched anteriorly, truncated posteriorly, slightly convex actinally.

Apical system slightly excentric in front; four perforated basal plates, the madreporite in the right anterior, and passing centrally, separating the postero-lateral basals and the posterior radials also, extending into the posterior interradium.

Ambulacra all in deep grooves; pores small and elongate in the anterior ambulacrum; large, except close to the apical system where they are minute, in the other ambulacra: petals open at the extremity close to the fasciole.

Peristome slightly excentric in front, broader than long, posterior lip well developed. Actinal plastron narrow. Periproct supramarginal, in the truncation.

Interradia with large sunken tubercles except in the posterior interradium. A peripetalous and a subanal fasciole.

Fossil. Miocene: Kachh.

Agassiz and Desor defined the genus *Plagionotus* in 1847, a name unfortunately preoccupied in the classification of the Insecta. Gray, in the Catal. Recent Ech. Brit. Mus. pt. i. 1855 (not 1832 as Dames writes), p. 50, admitted the name and separated

the genus from *Metalia*, a division of the genus *Brissus* (p. 51). His types were *Plagionotus pectoralis* and *P. Desorii. Brissus sternalis*, Lamk., sp., was his type of *Metalia*. A. Agassiz, 1872, Revision, p. 144, placed *Plagionotus* and *Metalia* as synonymous, and chose the latter subgeneric name to include *Plagionotus pectoralis* and *Metalia sternalis*. Since the time of the 'Revision,' the describers of recent Echinoidea have followed A. Agassiz; but that excellent palæontologist Dames has placed *Brissopsis* and *Toxobrissus* as synonyms of *Metalia*. It appears correct to admit the name *Metalia* instead of *Plagionotus*, to unite the species separated by Gray under this genus, and to place *Brissopsis* as an independent genus, with *Toxobrissus* and *Kleinia* as its synonyms.

Genus METALIA, Gray, 1855 (division), *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 51. *A. Agassiz*, 1872 (subgenus), *Revision*, pp. 144, 360. *Lovén*, 1874, *Etudes*, pl. 40, *sub* Plagionotus. (*Enlarged.*)

Syn. *Plagionotus*, Ag. and Desor, 1847, Gray, 1855, Lütken, 1863: *Xanthobrissus*, A. Ag., 1863; *Brissus*, Martens, 1869; *Brissopsis*, sensu Dames, 1877.

Test thin, moderate to very large, depressed, elliptical or ovoid in more or less wavy marginal outline, slightly indented anteriorly and truncated posteriorly, lowly arched or nearly flat abactinally, tumid above the margin, the edge of which is sharp; actinally comparatively flat.

Apical system excentric in front; the four basal plates perforated; the madreporite extending centrally and posteriorly, separating the postero-lateral basal and radial plates.

Ambulacra diverse; the anterior in a very shallow groove which may be absent near the apex, its pairs of pores rather distant and small; the petaloid parts of the paired ambulacra in variably sunken grooves, narrow, unequal and long, their pairs of pores large, nearly closing, with narrow interporiferous areas; anterior petals divergent, long, and straight or curved, those of the postero-lateral petals similar but rather close, and the zones bending with the distal ends flaring outwards or not, longer than those of the antero-lateral; actinally the postero-lateral ambulacral areas are long and narrow.

Interradia large, especially actinally, where the second and

third plates form much of the surface on either side of the narrow amphisternum, which, with the rest of the surface, is comparatively flat. Normal heteronomy of the interradium I. Great nipping-in of the interradial plates below the periproct.

Peristome excentric in front, crescent-shaped or subcircular, with a well-developed posterior labrum; the plates of the membrane well-developed. The periproct posterior and pear-shaped, in the truncated posterior surface, plated largely.

A peripetalous fasciole, elliptical, undulating or not. A broad subanal fasciole, surrounding a broad area, including six ambulacral plates on either side and grooves radiating to their pores. An incomplete anal fasciole, a vertical and small branch passing from the subanal or from a horizontal fasciole placed immediately above it, upwards on either side of the periproct, or in that direction.

Ornamentation abactinally either of very small close tubercles, the largest on the flanks of the anterior groove, or there may be numerous, yet distant, large primary tubercles in the lateral interradia, within the peripetalous fasciole. Beyond the fasciole the small tubercles gradually increase in size to the ambulacra at the peristome. Spines short, slender, curved, largest actinally and with a milled ring. Spheridia numerous, in groups in all the ambulacra.

Fossil. Eocene: Europe, Asia. Tertiary: N. America, W. Indies, Malta, Italy.

Recent. West Indian Islands, Florida, Mexico, Red Sea, Pacific Islands, East Indian Islands, Australia, Mauritius, E. Brazil, Sherboro Island, California, Mediterranean. Shallow water to 156 fms.

Genus RHINOBRISSUS, *A. Agassiz*, 1872, *Bull. Mus. Comp. Zoöl.* p. 111; *Revision*, 1872–4, p. 590; 1881, *Report on 'Challenger' Echini*, p. 186; 1883, *Report on 'Blake' Echini*, p. 67.

Test moderate in size, very thin, longer than broad and broader than high. Outline from above ovoid, with a narrow posterior end; broadest on a line with the apical system, which is nearly central or slightly in front. Vertex of the test posterior, and the posterior surface is tall, truncated, and hollowed transversely.

Apical system small, with four basal plates with large genital

openings. Madreporite extending backwards and separating the posterior radial plates.

Odd ambulacrum flush with the test, its pores exceedingly small. Lateral ambulacra short, sunken, subpetaloid; pores large and the poriferous zone broader than the interporiferous. Posterior ambulacra the longest. Ambulacra wide around the peristome and on either side of the actinal plastron.

Peristome broad, excentric in front, with a large posterior lip. Periproct high in the posterior extremity. Actinal plastron amphisternous, long, and prolonged posteriorly into a short beak, keeled along the median line. Three fascioles—a peripetalous, an anal, and an independent subanal fasciole.

Tubercles very small and numerous dorsally, and larger and with a raised scrobicular surface actinally. Large tufted ambulacral tubes close to the peristome. Spines small, curved.

Recent. China, Tahiti, shores of Belúchistán.

There is no doubt about the sunken nature of the lateral and posterior ambulacra in the species from the Pacific and Indian Seas, and that the outer terminations of the petals of the ambulacra are prevented from closing by the peripetalous fasciole. The madreporite is large and separates the basals, and extends backwards well into the interradium. Now none of these characters occur in a species which A. Agassiz refers to *Rhinobrissus* with an expression of doubt (Report on the 'Blake' Echini, 1883, p. 67). The figures given by Agassiz, pls. xxiii. and xxvi., show a most interesting form which is well deserving of the pains its describer took about its details and the relation which they bear to ancient forms of Spatangoids. He considers that the species will probably form the basis of a subgenus of *Rhinobrissus* which will hold to it very much the same relation which *Periaster* holds to the true species of *Schizaster*. But it must be said that the Caribbean Sea is not the home of the genus, and that the immature forms of the Indian species have the true generic characters given above and that the *Micraster*-look is wanting in them. The genus is not known in the fossil state, and the species *R. pyramidalis*, Agass., is not a variable one. It will be best to place the Caribbean form near the genera *Linopneustes* and *Cionobrissus* and in a new genus, *Neopneustes* (page 258).

Genus BRISSOPSIS, Agassiz, 1840, *Cat. Syst. Ectyp.* p. 16; 1847, *Cat. Rais. d'Éch., Ann. d. Sci. Nat.* sér. 3, vol. viii. p. 15. *Gray*, 1855, *Cat. Rec. Ech. Brit. Mus.* p. 55. *Desor*, 1858, *Synopsis*, p. 378. *Lovén*, 1874, *Études*, pls. xii. & xxxvi. *A. Agassiz*, 1872–4, *Revision*, pp. 354, 593. *Dames*, 1877, *Palæontographica*, Bd. xxv. p. 678. *Duncan & Sladen*, 1884, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, pt. iii. p. 203. *A. Agassiz*, 1883, '*Blake*' *Echini*, p. 69. (*Amended.*)

Syn. *Kleinia*, Gray; *Toxobrissus*, Desor; *Deakia*, Pavey; *Verbeekia*, Fritsch, 1877.

Test thin, moderate in size, ovoid or elongate-oval-elliptical in tumid marginal outline, depressed, lowly tumid dorsally, rounded in front and with a variable, shallow, anterior groove, truncated posteriorly, projecting and convex actinally and behind the peristome, or subglobular.

Apical system central or excentric in front; four basal plates; the pores large; the madreporite in the right anterior basal and passing centrally in the system and posteriorly so as to separate the posterior radial plates and some of the posterior interradial plates also.

Ambulacra diverse, unequal; the anterior slightly sunken dorsally, with small pairs of close pores most numerous abactinally; the antero-lateral sunken, subpetaloid, short, equal to but may be longer than the posterior pair, straight, divergent, or curved more or less; pairs of pores large and in parallel rows, with small interporiferous areas. Postero-lateral ambulacra straight or curved, sunken; pairs of pores as in the antero-lateral, but the anterior row may become continuous with the posterior row of the antero-lateral ambulacra, subpetaloid and tending or not to close at the fasciole; actinally the areas are bare and large, those of the postero-lateral form wide areas at the sides of the plastron, and four (the 6–9 inclusive) plates of the rows nearest the plastron are angular, with large pores, and are within the subanal fasciole.

Interradia narrow apically, large actinally; the right posterior with normal heteronomy of its plates (union of 2 and 3 of series *a*). A symmetrical amphisternum. Tubercles small and crowded abactinally, larger actinally, largest at the margins of the bare ambulacra near the peristome. Periproct, in the truncated posterior surface, elliptical or ovoid, longitudinal.

A subanal fasciole, concave towards the distant periproct, with or without anal branches; a peripetalous fasciole well developed, more or less flexuous. Plates of the membranes of the peristome and periproct largest at the edges and smaller near the orifices.

Fossil. Eocene: England, Europe, Asia, Java. Miocene: Europe, N. America, W. Indies. Pliocene: England, Europe.

Recent. North Atlantic, Norwegian and British seas, Mediterranean, Florida Gulf-stream, Sombrero, Caribbean Islands, Formosa, Siam, East Indies, New Caledonia, Luzon, Tahiti, New Zealand. Range from 1100 to 2435 fms.

The curving of the paired ambulacra is well seen in the Sindian species, and it is evident that such a character is not sufficient to separate a new genus; moreover the continuation of the rows of pairs of pores so as to form a curve across the postero-lateral interradia is subject to great variation. The general shape of individuals of the same species is remarkable and has necessitated the introduction of an alteration in the definition of the genus; this is the result of A. Agassiz's examination of the Echini of the 'Blake' dredging-expedition.

M. Cotteau defined a genus *Cyclaster* in 1856, and Desor placed it as a synonym of *Brissopsis* in his 'Synopsis,' 1858. In 1863 M. Cotteau reasserted the right of *Cyclaster* to a generic position, and wrote that *Brissopsis* differed because it had an anterior groove and very slightly divergent and atrophied paired ambulacra. Dames described and drew two species of *Cyclaster* in 'Palæontographica,' 1877, Bd. xxv.; and his figures and descriptions agree with M. Cotteau's ideas; but there is no vestige of a peripetalous fasciole, and there are four closely-placed genital pores. It is possible that the fasciole may have been worn off; nevertheless the ornamentation of the test is given without any evidence of it. Since that time several species have been removed from *Cyclaster* by M. Cotteau, and a fresh generic character has been added by him to which exception must be taken.

The characters relied upon are the absence of an anterior ambital groove, the divergent antero-lateral ambulacra, a peripetalous fasciole which is somewhat angular, a subanal fasciole, and the presence of only three genital pores, that of the right anterior basal plate being absent; the extension of the madreporite centrally, with separation of the posterior basal plates. In 1887,

however, M. Cotteau admitted *C. Gourdoni*, which he showed has an imperfect peripetalous fasciole and a test differently shaped from that of the type.

The researches of A. Agassiz regarding the recent species of *Brissopsis* in the W. Indies have proved that some forms have divergent antero-lateral ambulacra, especially the young, that there is considerable variation in the depth of the ambital groove, and that during growth the ambulacra are closer. (A. Agassiz, 1872–74, Revision, pl. xix. figs. 8, 9; 1883, 'Blake' Echini, pl. xxvi.)

The presence of four genital pores in some and three in other species is not important; and the abortion of a duct and its gland is of no more classificatory value in this group than it is in others. The position of *Cyclaster* is that of a subgenus.

Subgenus CYCLASTER, *Cotteau in Leymerie et Cotteau* (genus), 1856, *Cat. Éch. Foss. de Pyrén.* p. 27 (*Extr. Bull. Soc. Géol. de Fr.* sér. 2, vol. xiii.); 1863, *Éch. Foss. des Pyrén., Cong. Sci. de France*, 28 Sept. vol. iii. p. 57; 1887, *Pal. Fr., Terr. Éocène*, p. 447, pl. 123, *and Bull. Soc. Zool. de Fr.* vol. xii. pp. 564 & 632.

Anterior groove slight abactinally, lost at the ambitus. Antero-lateral ambulacra divergent.

Apical system with three or four genital pores, and a central madreporite separating the posterior basal plates. Peripetalous fasciole subcircular, often more or less deficient; a subanal fasciole.

Fossil. Eocene: Europe, N. Africa?

Genus BRISSOPATAGUS, *Cotteau*, 1863, *Éch. Foss. de Pyrén.* p. 143. *Dames*, 1877, *Palæontog.* Bd. xxv. p. 82, pl. xi. fig. 2. *Duncan & Sladen*, 1884, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 226. (*Amended.*)

Test of medium size, oval, moderately tumid abactinally, lower and subcarinate posteriorly, flat actinally, anterior groove moderate at the ambitus, but small abactinally; broad depressed areas around and including the petaloid parts of the lateral ambulacra; a definite interradial ridge separating the lateral petals.

Apical system excentric in front. Anterior ambulacrum with small pores and in a slight depression; anterior pair short, widely divergent, much curved, concavity forwards, not closing; pores

large; posterior pair longest, curved, with the concavity outwards, unclosed distally; all in the depressions of the test, forming an acute angle at the apex.

Peristome excentric in front, subcircular. Periproct elliptical, posterior. Fascioles: a peripetalous and a subanal.

Fossil. Eocene: Europe, Asia, Sind; and Java (Tertiary).

Dames drew a distinct peripetalous fasciole; and in Duncan and Sladen's specimens there is every indication of a subanal.

In the species described by Dames there are some primary tubercles scattered in the lateral interradia.

The genus should come near *Brissopsis*.

Genus SPATANGUS, Klein, 1734, *Nat. Disp. Ech.* p. 33. *Lamarck*, 1801, *Syst. Anim. s. Vert.* p. 348. *Gray*, 1825, *Ann. Phil.* vol. x. p. 8; 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 46. *Desor*, 1858, *Synopsis*, p. 419. *A. Agassiz*, 1872–74, *Revision*, pp. 158, 564. *Lovén*, 1874, *Études*, pls. 208–212.

Test thin, large, cordiform in marginal outline, broad, rounded and grooved anteriorly, truncated at the narrower and oblique posterior surface, dorsally slanting upwards and backwards, depressed, never as high as broad.

Apical system small, slightly excentric in front and in front of the vertex; four basal plates perforated; and the madreporite extending between the postero-lateral basal plates and between the posterior radial plates into the interradium. Anterior ambulacrum in the broad deep groove; pairs of small pores distant. Antero-lateral ambulacra with the petaloid parts broad, long, divergent; the interporiferous areas tumid and flush; the poriferous zones broad, sunken; the pores small in the anterior zone near the apex, large where the zones are large, closing at an angle distally; anterior poriferous zone may be ill-developed. Postero-lateral ambulacra broad, petaloid, closed, subequal to the antero-lateral, and with large flush interporiferous areas and sunken poriferous zones. Actinally the ambulacra form most of the peristomial margin anteriorly and at the sides; and the postero-lateral ambulacra are well developed, the 6–8 plates of the inner zones being within the subanal fasciole, and two with large perforations.

Peristome excentric in front, with a projecting labrum; an amphisternum. Periproct large, supramarginal, elliptical, trans-

verse; both the periproct and peristomial membranes largely plated near the test.

Normal heteronomy of the right postero-lateral interradium.

A subanal fasciole only, including a broad plastron beneath the periproct.

Ornamentation abactinally, in the interradia, of large primary tubercles, slightly sunken in scrobicules, crenulate and perforated, scattered or in more or less wavy rows, and of close small secondary tubercles and a minuter tuberculation and granulation; actinally the tubercles are close and occur on the plastron. Spines longest and largest on the larger tubercles, slender, pointed, curved, striated; those of the smaller tubercles are of the same shape as the larger spines.

Fossil. Tertiary?: England, Europe.

Recent. Shores of N. Atlantic and German Oceans, Mediterranean, Azores, Bermuda, Caribbean Sea, Cape of Good Hope, Japan; Red Sea? 150 to 450 fms.

The definition of *Loncophorus*, which has been attributed to Dames, has not been discovered, unless Laube's definition of *Concophorus*, Denkschr. k. Akad. Wien, Bd. xxix. p. 36 (1869), is to be taken. Dames noticed the species called *Spatangus loncophorus*, Meneg., in his description of the "Vicent. u. Veron. Tert. Ech.," Palæontogr. 1877, p. 83, and wondered at Laube's etymology. It does not appear that a generic definition was produced.

Subgenus LONCOPHORUS, *Dames*?

Syn. *Concophorus*, Laube.

Spatangi without large primary tubercles on the interradia dorsally.

Fossil. Tertiary: Europe.

Genus MARETIA, *Gray*, 1855 (a division of *Spatangus*), *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 48. *Lovén*, 1874, *Études*, pl. xlii. *A. Agassiz*, 1872–74, *Revision*, p. 568.

Test moderately thin, cordiform or ovoid, depressed, slightly tumid dorsally; anterior groove slight; posterior truncation narrow, actinally flat.

Apical system slightly excentric in front, small, four close

perforated basal plates; madreporite separating the lateral basals and extending backwards.

Ambulacra diverse, the anterior narrow, with few pairs of pores; paired ambulacra long, extending to the ambitus as broad, shallow unequal petals; the interporiferous areas broad and tumid or not; the poriferous zones closing, broad; and the anterior zone of the antero-lateral ambulacra may have small or aborted pores.

Actinally the ambulacral areas are very broad posteriorly and bare; the peristome with a long narrow labrum and a very narrow and small amphisternum. Periproct large, in the truncation.

Normal heteronomy of the right postero-lateral interradium.

Ornamentation of sunken primary tubercles crenulated and perforated, either numerous and in rows in the anterior and lateral interradia, or few in the lateral and postero-lateral interradia. A subanal fasciole, and evidences of a discontinuous peripetalous fasciole or not. Spines small, usually pointing backwards, longest actinally on either side of the ambulacra. Actinal plastron comparatively bare.

Fossil. Tertiary: Europe, India, Java, Australia.

Recent. Masbate, Borneo, China, Kingsmill Is., New Caledonia, Mauritius, Australia, Levuka Reef, Japan, Arafura Sea, South Sea. 25–800 fms.

Genus Eupatagus, *Agassiz*, 1847, *Catal. Rais.*, *Ann. d. Sci. Nat.* sér. 3, vol. viii. p. 9. *Gray*, 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 49. *Duncan & Sladen*, 1884, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 235, pl. xxxviii. figs. 11–13.

Syn. *Euspatangus.*

Test of moderate size, thin, elongate, cordiform, tumid but depressed dorsally, narrowest and truncated posteriorly, actinally flat, with a slight keel.

Apical system small, excentric in front, with four basal plates, perforated; the madreporite in the right anterior basal plate, extending to the centre and posteriorly, and separating the postero-lateral basal plates and posterior radial plates.

Ambulacra diverse; the anterior in a feeble abactinal depression, narrow, and with distant small pairs of pores; the paired ambulacra petaloid dorsally, long, wide, closed; the interpori-

ferous areas broad and pointed distally, not depressed, and may be tumid; poriferous zones broad, closing, more or less sunken; pores dissimilar.

Peristome excentric in front, semilunar or subcircular, with a projecting posterior labrum. An amphisternum bounded by wide ambulacral areas. Periproct occupying much of the posterior truncation. A peripetalous fasciole, elliptical and circumscribing the petaloid parts of the ambulacra. A subanal fasciole, cordiform or broadly reniform in shape.

Tuberculation—some large perforated and crenulated scrobiculate primary tubercles, sparely distributed upon the anterior and lateral interradia, circumscribed by the fasciole; elsewhere absent; a small tuberculation, and miliaries largest actinally. Spines short, the largest bent, tufted on the subanal area.

Fossil. Eocene: Europe, N. Africa, Asia. Miocene: Australia and W. Indies.

Recent. Australia, N. S. Wales, Arafura Sea, Van Diemen's Land.

A difficult question has arisen regarding the genus *Macropneustes*, Agassiz, 1847. The genus was founded and the diagnosis appeared in Cat. Rais., Ann. Sci. Nat. sér. 3, vol. viii. p. 8, figured in vol. vi., pl. xvi. fig. 2 (1846–47).

Macropneustes Deshayesi was the type, and was supposed to show the generic characters; but in after years it became evident that the specimen used by Agassiz was worn and useless; for good ones showed a subanal besides the peripetalous fasciole.

In the meantime Cotteau had founded *Peripneustes* for species which were *Macropneustes* with a subanal fasciole. To add to the confusion, some *Macropneustes* were described which tallied with the written diagnosis of Agassiz, and had no subanal fasciole.

No two writers are agreed about the nature of the ambulacra in *Macropneustes*, whether they are flush or in grooves.

There is always a desire to retain the genus of an old and valued naturalist; but it is clear that if *Macropneustes* is to be retained, *Peripneustes* must become its synonym, and the Agassizian genus must be altered. Again, if *Macropneustes* is altered, the species which tally with the original generic definition must find a home elsewhere.

Any one who has had the opportunity of studying the method

of Agassiz would not have much difficulty in believing that if he had known that there was a subanal fasciole present, he would have regarded the species as one of a group of *Eupatagus*. Dames, in considering an Eocene *Peripneustes*, noticed how close the form was to *Eupatagus*, and if *E. avellana* from Sind is examined the alliance is evident. There is, however, the question about the taxonomic value of flush and grooved ambulacra. This is to a certain extent answered, because there are forms intermediate between the perfectly flush broad ambulacra of *Eupatagus* and the grooved ambulacra of *Peripneustes*, and the Sindian species *Macropneustes speciosus* and *Eupatagus avellana* are intermediate to a certain extent.

It is proposed to make *Macropneustes* and *Peripneustes* synonymous, as Cotteau has done, and to place the first as a subgenus of *Eupatagus* (*Euspatangus*). The diagnosis of the subgenus will have to receive the addition of "a subanal fasciole, and the ambulacra semiflush or in grooves."

This will place A. Agassiz's recent *Macropneustes spatangoides*, 1883, 'Blake' Echini, p. 64, in a subgenus of *Eupatagus*.

There remain a considerable number of species which were properly considered to belong to *Macropneustes*, Agassiz, 1847 (not in reference to the type-species). Most have more or less flush ambulacral petals, and rather large tubercles within the peripetalous fasciole. They must enter *Hypsopatagus*, Pomel, 1883 (see *ante*, p. 239).

Peripneustes was founded by Cotteau, 1875, Kongl. Svensk. Vet.-Akad. Handl. Bd. xiii. No. 6, p. 38, pl. vii.; and considered by Dames, 1877, Palæontographica, xxv., Ech. Vic. Tert. p. 73; Duncan & Sladen, 1883, Pal. Ind. ser. xiv. Ech. Kachh & Kattywar, p. 41. *Trachypatagus*, Pomel, 1883, Thèses, p. 31, is a synonym.

Subgenus Macropneustes, *Agassiz* (genus), 1847, *Catal. Rais.*, *Ann. d. Sci. Nat.* sér. 3, vol. viii. p. 8. (Figure of the typical species, vol. vi. pl. xvi. figs. 2, 2*a*.) (Pars.) (*Enlarged.*)

Syn. *Peripneustes*, Cotteau, 1875. *Trachypatagus*, Pomel, 1883. *Stomaporus*, Cott. 1888. *Isopneustes*, Pomel?

Test thick, tumid; ambulacral petals elongate or broad, grooved or semiflush, open or imperfectly closed; poriferous zones equalling the interporiferous area in breadth. Tubercles large, upon the interradial areas, but less projecting than the tubercles

of *Spatangus*. A lateral fasciole at the height above the margin of the test, corresponding to the ends of the ambulacral petals, passing above the anus. A subanal fasciole.

Fossil. Eocene: Europe; Africa; W. Indies: Asia.

Recent. Caribbean Sea.

Stomaporus, Cotteau, 1888, Compt. Rend. vol. cvii., differs because it has a sharp edge and an almost central peristome, but it can hardly be otherwise than one of this group.

Genus NACOSPATANGUS, *A. Agassiz*, 1873 (subgenus), *Bull. Mus. Comp. Zoöl.* vol. iii. p. 189; 1874, *Zool. 'Hassler' Exped.*, *Cat. Mus. Comp. Zoöl. Harv.* No. viii. 1. *Echini*, p. 17.

Test small, thin, ovoid in tumid marginal outline, arching regularly dorsally to the vertex, which is between the apical system and the nearly vertical posterior truncation, broadest in front of the centre, narrow behind, without an anterior groove.

Apical system slightly excentric in front, small, with three perforated basal plates, and the madreporite in the right anterior, which is imperforate.

Anterior ambulacrum different from the others, the interporiferous area covered with small secondaries and miliaries; pores small. Antero-lateral ambulacra flush, with slightly sunken poriferous zones; the anterior poriferous zone with single pores, the posterior with large pairs of pores which become single actinally. The postero-lateral ambulacra with broad poriferous zones and a narrow interporiferous area, petaloid and nearly closing.

Peristome large, excentric in front, semilunar, plated, with a broadly projecting labrum. The sternum narrow, keeled, tuberculate, flanked by broad ambulacral areas. Periproct posterior, transversely elliptical, with two concentric rows of anal plates, below it a subanal plastron with a fasciole, and a beak at the lower end of this plastron which is continuous with the actinal surface. Some anal branches of the subanal fasciole. Spines longest actinally, short and curved at the base.

Recent. Juan Fernandez, 65 fathoms.

The generic characters of *Gualtieria*, Desor, have necessarily been enlarged by the discovery by M. Cotteau of a subanal fasciole in the typical species from Saint Palais.

Genus GUALTIERIA, Desor, 1847, *Catal. Rais., Ann d. Sci. Nat.* vol. viii. p. 10. Desor, 1858, *Synopsis*, p. 406. *Cotteau*, 1884, *Éch. de Saint Palais*, p. 32, *Ann. d. Sc. Géol.* vol. xvi. pl. vi.

Test moderate in size, ovoid elliptical in marginal outline, rounded in front, without a deep groove, slightly narrower behind and truncated, very tumid but low dorsally, flat actinally except behind the peristome, where there is some convexity.

Apical system pentagonal, with four basal plates, each with a large pore; the madreporite extending centrally, and separating the postero-lateral basal plates, and also the posterior radial plates.

Ambulacra diverse, the anterior in a slight depression abactinally, broad, with the pairs of small pores arranged obliquely; the paired ambulacra long, flush, petaloid, tending to but not closing; the anterior poriferous zone of the antero-lateral pair with small pores near the apex, elsewhere the poriferous zones broad; the interporiferous area broad, and the whole flexuous; the postero-lateral ambulacra straighter, with the poriferous zones broad.

Peristome transverse, broadly elliptical, with a narrow labrum which is long, and has an amphisternum beyond; peristomial interradial plates of the antero-lateral areas tuberculate, and the labrum also. The long posterior ambulacra and the anterior ambulacrum are ornamented with raised irregular prominences. Periproct posterior, high up, oval, longitudinal.

A well-defined fasciole crosses all the ambulacra at the distance of three quarters of their length from the apical system, without interfering with the nature of the pairs of pores. An elliptical bent subanal fasciole enclosing a broad area.

Fossil. Eocene: Europe.

Genus LINOPNEUSTES, *A. Agassiz*, 1881 (subgenus), *Report on the 'Challenger' Echini*, p. 167; 1883, *'Blake' Echini*, p. 62.

Syn. *Palæopneustes*, A. Ag. (pars).

Test large, depressed, but rather subhemispherical abactinally, the posterior part of the test sloping gradually; oval in ambital outline and notched in front, and may be slightly so posteriorly; flat actinally, with a low median keel behind the peristome.

Apical system central or slightly excentric in front, with four perforated basal plates; the madreporite extending from the right

anterior basal, centrally and posteriorly, so as to separate the postero-lateral basal plates and the posterior radial plates, and extend into the posterior interradium.

Ambulacra dissimilar, the anterior in a faint groove, with small pairs of round pores; the paired ambulacra semipetaloid, flush, all open distally, the antero-lateral widely divergent dorsally, and the postero-lateral with broad smooth plates on either side of the amphisternum; the pores of the semipetaloid parts round, but the outer pore of the pairs may be slightly elongate; pores single and distant below the semipetaloid parts, and some with peripodia around the peristome.

Peristome excentric in front, in a moderate concavity of the test, much broader than long, semi-lunar with rounded ends. Posterior labrum broad, projecting. Sternum with a more or less defined keel (amphisternous). Periproct supramarginal, circular, much plated.

Ornamentation of few or numerous small primary tubercles on each plate abactinally, edges and sutures of plates more or less plain; miliaries between the tubercles. Actinally the tubercles are subequal and more crowded, and most numerous within and around the subanal fasciole. Primary spines long or short, slender, curved, smallest actinally. Pedicellariæ long; the tridactyle forms with slender valves. Ambulacra with much smaller tubercles beyond the subpetaloid part than in the interradia.

A narrow peripetalous fasciole passing above the periproct; a subanal fasciole, broad or narrow heart-shaped, partly in contact with the actinal edge of the periproct.

Recent. Caribbean Sea, 38 to 298 fathoms; Japan and the Philippine Islands, 345 to 375 fathoms.

The species which is found in the deepest water has the shortest spines and the ambulacra the most apetaloid.

Genus Neopneustes, gen. nov.

Syn. *Rhinobrissus*, A. Agassiz, 1883, 'Blake' Echini, p. 67, pls. 23 & 26 (pars).

Test moderate in size, thin, ovoid in outline at the margin, longer than broad and broader than high; tumid abactinally, at the sides; low, broadest and tumid anteriorly, highest and truncated posteriorly; with a backward and downward projecting actinal plastron. Anterior groove absent.

Apical system slightly excentric in front, small, with four perforated basals, compact (?).

Ambulacra flush with the test, apetalous, diverse, with high plates, broad actinally, and the tentacles tufted around the peristome. The anterior ambulacrum narrow and with distant pairs of very small pores; the antero-lateral widely divergent, the postero-lateral closer.

Peristome excentric in front, broad, semilunar, with a projecting posterior lip. Actinal plastron projecting, and carrying small, short and crowded spines. Periproct small, oval, longitudinal, in the posterior truncation of the test, rather high up.

A peripetalous fasciole, sometimes ill-defined, passing around the apex about midway between it and the ambitus and crossing the ambulacra, without affecting their structure. A well-marked subanal fasciole surrounding the blunt end of the keel. Tubercles small; spines small and short, largest actinally, especially in front of the peristome.

Recent. Caribbean Sea, 175–233 fathoms.

The genus *Cionobrissus*, A. Agassiz, has one species, *C. revinctus*, which was dredged up in the Arafura Sea by H.M.S. 'Challenger' from 800 fathoms. The species is described in the Report on the Echinoidea of the 'Challenger,' and a previous notice both of the species and genus will be found in Proc. Amer. Acad. vol. xiv. p. 206 (1879).

The generic diagnosis reproduced in the 'Challenger' Report, p. 187 (1881), is mainly comparative. I give a diagnosis which has been abstracted from the description of the species by A. Agassiz, and tested by the drawings (Report, p. 187, pl. xxiii.).

Genus Cionobrissus, *A. Agassiz*, 1879, *Proc. Amer. Acad.* xiv. p. 14, p. 206; 1883, *Report on 'Challenger' Echini*, p. 187.

The test is of moderate size, long, subcylindrical, depressed, ovoid in marginal contour, with a notch in front and a beak behind, tumid above and at the sides, and with a convex actinal surface which is keeled broadly as far as a posterior beak. Test highest in the posterior third, longer than broad, and about as broad as high; rounded anteriorly, where there is a broad

and rather deep groove extending from the apex to the peristome; posteriorly there is a decided beak, above which is the periproct, circular in outline, and situated in the posterior truncation.

Apical system excentric in front; there are four basal plates, and they are perforated by the generative ducts; the madreporite is in the usual basal, and it passes backwards between the posterior basals and radials into the posterior interradium.

The ambulacra dissimilar; the anterior is sunken, and there is a pair of minute pores to each of its plates. The other ambulacra are subpetaloid, not closing, and in very slight grooves. The antero-lateral are the shortest and are nearly transverse; and in all the poriferous zones are wide, the pores being unequal, and the interporiferous areas being very narrow. The exceedingly shallow ambulacra are almost devoid of tubercles.

The interradia are unequal, the posterior being the narrowest; there are a few large primary tubercles in each within the peripetalous fasciole; elsewhere the ornamentation is of rows of large granules, but it is largest on the keel and the extremity of the beak.

Peristome excentric in front, semi-lunar, broader than long, with a small posterior lip. Periproct small, circular, many-plated, just above the plates surrounding the upper part of the beak. Beak blunt, slanting from below upwards, and with a comparatively level upper surface.

Subanal fasciole surrounding the base of the keel, ovoid, with the point downwards. Peripetalous fasciole oblique, narrow and extending across the ends of the ambulacra and cutting across the anterior groove far above the peristome. The sternum arched and keeled. The tubercles within the fascioles carry long curved spines, elsewhere they are shorter, except on the sternum.

Recent. Arafura Sea, 800 fathoms.

Alex. Agassiz, in his description of the genus, remarks that the genus forms a transition between his Brissina and the Pourtalesiidæ. The groove of the anterior ambulacrum is far less marked than in the Pourtalesiidæ. The actinal surface is not flattened as in the last-mentioned family, but arched. The arrangement of the tubercles in the interradia within the peripetalous fasciole is like that of some species of *Metalia.*

The genus *Tuberaster*, 1885, Peron et Gauthier, Éch. foss. de

l'Algér. fasc. ix. p. 46, pl. iii. figs. 1–4, is not a satisfactory genus, and there is little evidence of an internal or of a peripetalous fasciole; indeed, Humbert does not draw a subanal. It is therefore not placed. If the fascioles were present, the genus would be *Lovenia* (see p. 263), and if absent, *Hemipatagus* (p. 222).

Genus Echinocardium, *Gray*, 1825, *Annals Phil.* p. 8; 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 42. *Lovén*, 1874, *Études*, p. 55, pls. 3, 12, & 39; 1883, *Pourtalesia*, pls. 15, 17.

Syn. *Amphidetus*, Agass.; *Amphidotus*, Forb.

Test moderate, thin, cordiform or oval in tumid marginal outline, gibbous, deeply and broadly grooved in front, truncated and highest behind; broader than high, rather flat dorsally in front, high and broadly keeled behind the vertex, which is behind the centre. Actinally with a tumid plastron projecting downwards, a prominent labrum, and a sharp end to the plastron behind.

Apical system at the termination of the abactinal groove, excentric posteriorly, small, with four basals with large pores; the madreporite extending between and in the rear of the postero-lateral basals; the radial plates small.

Anterior ambulacrum in the groove; the pores small, single, and irregular, or in pairs sometimes biserial or alternating where included within the internal fasciole, and close near the apex, where the tentacles have crenulated or stellate disks with a central bulge and one or two large spicules. The pores are larger and more distant anteriorly, where there are simple locomotive tentacles with peripodia and penicillate tentacles, as actinally. Lateral ambulacra in slight grooves, triangular in outline, widely open towards the apical system, where they are limited by the internal fasciole, narrow distally; the pairs of pores large and not numerous; the outer poriferous zones forming an arch with a slight discontinuity; the tentacles branchial. Actinally the ambulacra are plain and rather broad near the peristome, but narrow on either side of the plastron; the peripodia with capitate filaments.

Peristome large, semilunar, with well-developed membrane-plates, which are largest anteriorly, the anterior lip at a much higher level than the posterior, which is pointed and blunt. Spheridia exposed.

Interradia narrow above, large actinally, all with a single

peristomial plate; the plates 2 and 3 of zone "*a*" of the right posterior interradium united; an amphisternum.

Periproct, high up in the posterior face, elliptical, vertical, with well-developed plates, largest at the edge. Tubercles largest actinally, with short delicate, often spatulate spines, smaller and crowded abactinally with shorter and silky spines.

Fascioles, an internal, an anal not closing above, and a closed subanal, including three ambulacral pores on either side, belonging to 7th to 9th plates, with penicillate tentacles.

Fossil. Eocene: ? Europe. Miocene: Europe. Late Tertiary: England, N. America.

Recent. N. British and Scottish seas, N. Atlantic, Mediterranean, Japan, E. Indian seas, E. Africa, Cape of Good Hope, Australian and N. Zealand seas, Florida, N. & S. Carolina, Brazil. Littoral to 2675 fms.

Genus Breynia, *Desor*, 1847, *Ann. Sc. Nat. Zool.* sér. 3, vol. viii. p. 12. *Gray*, 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 45. *A. Agassiz*, 1872–4, *Revision*, p. 578. *Lovén*, 1874, *Études*, pl. 41; 1883, *Pourtalesia*, p. 55. *Duncan & Sladen*, 1885, *Pal. Ind.* ser. xiv., *Foss. Ech. W. Sind*, p. 342, pl. lv.

Test moderate and large, thick, ovoid or cordiform in tumid marginal outline, depressed, flatly arched dorsally, highest behind the centre, rounded and notched in front, obliquely truncated behind, actinally resting on a spot anterior to the peristome, and on the posterior point of the small triangular plastron.

Apical system in front of the vertex, small, with four basal plates; the madreporite separating the basal plates, and extending posteriorly and separating the posterior radial plates.

Anterior ambulacrum in a more or less decided groove, which notches the anterior part of the test, the single pores numerous dorsally; tentacles long, slender, truncated, and with small processes; and beyond the crossing of the inner fasciole, anteriorly, the pores are larger and more distant. Lateral ambulacra triangular beyond the internal fasciole, with few small single pores converging to the apical system, within its area; the outer series of pores in pairs large and separated by costæ. The antero-lateral ambulacra nearly transverse, the postero-lateral straight or wavy and not very distant distally; pairs of pores as in the antero-lateral ambulacra. Actinally the posterior ambulacra have wide zones which limit the plastron.

Lateral interradia with large plates next to the very small peristomial ones; plates 2 and 3 of zone "*a*" of the right posterior interradium united. Posterior labrum elongate; sternum symmetrical and small.

Peristome semilunar, open, the margin nearly formed by ambulacral plates, the interradial plates just entering or not, except the posterior, which forms a labrum. Periproct in the posterior truncation, in a depression, ovoid. Tubercles small upon the actinal surface and on the margin. Several large perforate scrobiculate sunken primary tubercles, their mamelon small and doubtfully crenulate, in all the interradia, except the posterior, dorsally.

An internal fasciole closed; a subanal, broad, closed, environing six of the ambulacral pores on either side beyond the fifth plates; a peripetalous fasciole passing beyond the petaloid parts of the ambulacra and limiting the great tubercles.

The spines of the large tubercles, none of which are on the posterior interradium dorsally, are long, slender, curved; the actinal spines very small and slender.

Fossil. Miocene: E. India; Europe?

Recent. Red Sea, Japan, Sandwich Islands, Australia.

The species said to be Eocene by d'Archiac and Haime are now known to be Miocene, and the species described by M. Cotteau from the Antilles are not members of the genus according to Desor.

Genus Lovenia, *Agassiz & Desor*, 1847, *Catal. Rais., Ann. d. Sci. Nat.* vol. viii. p. 10. *Gray*, 1855, *Cat. Rec. Ech. Brit. Mus.* pt. i. p. 44. *A. Agassiz*, 1872–74, *Revision*, pp. 139, 574. *Lovén*, 1874, *Études*, pl. xliii. *Duncan*, 1877, *Quart. Journ. Geol. Soc.* vol. xxxiii p. 58, pl. iv. figs. 5–8. *McCoy*, 1879, *Pal. Vict. Geol. Surv.* decad. vi. p. 37.

Syn. *Sarsella*, Pomel; *Tuberaster*, Peron?

Test moderate or rather small in size, variable in thickness, thin or rather stout, cordiform or ovoid, depressed or rather tumid in the thick forms; an anterior groove and a posterior truncation.

Apical system excentric in front, with four perforated basals, and the madreporite separating the posterior basals and radial plates.

Ambulacra diverse, interfered with by the internal fasciole; lateral petaloid ambulacra flush, with the poriferous zones sunken, with their outer poriferous zones forming a more or less crescentic tract; the anterior poriferous zones of the antero-lateral petals nearly transverse, and with pairs of pores more or less aborted within the fasciole. Anterior ambulacrum in the groove, narrow, with small pairs within the fasciole.

Peristome excentric in front, subcircular or semilunar, the labrum narrow but very long, followed by a small amphisternum, which, with the adjacent broad ambulacral areas, forms a wide space comparatively free from tubercles. Large tubercles, abactinally, varying in number, scrobiculate, crenulate and perforated on the interradia except the posterior; in the thin tests the scrobicules form prominent parts ("purses") within the test, but not or only slightly in thick tests.

Interradia with the second and third actinal plates of the lateral interradia very large; and union of the plates 2 and 3 of zone *a* of the right posterior interradium. Periproct large, in the posterior truncation.

An internal fasciole crossing the petaloid parts of the antero-lateral ambulacra, and bounding the anterior groove and crossing the anterior odd ambulacrum. A subanal fasciole including the 6–9 inner ambulacral plates, three or more pairs of pores being large and within the elongate transverse fasciolar area on either side.

Spines, pointing backwards, long and slender actinally and laterally, short elsewhere, those within the subanal area projecting backwards in two tufts. Anal plates large near the circumference.

Fossil. Tertiary: Crimea, Corsica, Malta, Algiers, Java, Australia, New Zealand.

Recent. Guayaquil, Gulf of California, Red Sea, Australia, Philippines, Arafura Sea, Cape of Good Hope, China, Japan, Sandwich Islands. 10 to 28 fms.

The small forms with thick tests found in the Australian Tertiaries show slight vestiges of the internal scrobicular pouches, so that the genus has been modified in 1877 to receive them; there is no room for a new subgenus, such as *Sarsella*, which would include such forms according to M. Pomel (Thèses, 1883, p. 36).

The *Spatangus* referred by Dr. Wright to *S. ocellatus*, Desor, from Malta, is a true *Lovenia*.*

* The jumble which some palæontologists have made of *Lovenia*, *Sarsella*, *Maretia*, and *Hemipatagus* is great. It is necessary, in the first instance, to consider *Sarsella mauritanica*, Pomel, quoted by M. Cotteau, Éch. foss. de l'Algér. fasc. ix. 1885, p. 36, pl. i. M. Pomel diagnosed *Sarsella* as a subgenus of *Lovenia* without the internal swellings of the test. It has been shown that this character depends upon the thickness of the tests and is not more than of specific value. On page 37 M. Cotteau tells us that "Les fascioles [in the species under consideration] ne sont visibles sur aucun de nos examplaires, et malgré l'oblitération des pores, près du sommet, nous ne sommes pas absolument certains qu'il y ait eu un fasciole interne. . . . Aussi avons nous longtemps hésité au sujet de l'attribution générique de cette espèce au genre *Sarsella* ou au genre *Maretia*." Further on M. Cotteau states:—" M. Pomel tout en rapellant en tête de sa description, que son genre *Sarsella* est muni de ce fasciole, n'*affirme pas nettement l'avoir distingué sur ces exemplaires*, et il n'en donne aucun détail." Now, although M. Cotteau had this knowledge before him, he did not put the subgenus on one side, but recognized it as a genus. The palæontologists, Messrs. Etheridge, McCoy, T. Woods, and the author of this Revision, who examined and described the Australian *Loveniæ* and classified them, have then little to thank MM. Pomel and Cotteau for, in removing their well-established genus and species to a subgenus or genus which has not had its type sufficiently defined to be of the slightest value. One would have thought that the absence of fascioles and the general appearance of the African species would have been of some weight when M. Cotteau, after doubting between *Lovenia*, *Sarsella*, and *Maretia*, thought of *Hemipatagus*, Desor, as a possible genus. He considers, however, that the resemblance is " assez loin," and adds that the two types belong to different horizons, and in fact are very easily distinguished. He then gives the distinctions to be the variation in the number of the large interradial tubercles, their being higher up in the African form, and this is also less swollen. Now these are no distinctions; and from Humbert's usual good drawing there can be little doubt that an internal fasciole never was present in many, that the petals are unlike those of *Lovenia*, and that there is great doubt about a subanal fasciole.

Sarsella therefore is not a good group, and whilst some of its species would be true *Loveniæ*, such as the Australian, the type *S. mauritanica*, Pomel, is a *Hemipatagus*.

M. Pomel has found out that *Breynia sulcata*, Haime, is a *Sarsella*. He has never seen the type, and I have had that advantage, and have not the slightest doubt that he is mistaken, and that it is one of the most typical of the genus *Breynia*.

IV. Division *Apetala.*

Spatangoidea with flush, apetalous, and generally uniporous, ambulacra, similar or may be diverse; plates high, few, often hexagonal. Apical system usually ethmophract; phyllodian pedicels with a simple marginal row of filaments. Fascioles present or absent.

Section Adetes.
Genus *Genicopatagus.*
Palæobrissus.
Section Prymnadetes.
Genus *Aceste.*
Aërope.
Section Prymnodesmia.
Genus *Ovulaster.*
Palæotropus.
Homolampas.
Argopatagus.
Cleistechinus.

IV. Division *Apetala.*

Section *Adetes.* (Without fascioles.)

Genus Genicopatagus, *A. Agassiz*, 1879, *Proc. Am. Acad.* xiv. p. 210; 1881, *Report on the 'Challenger' Echini*, p. 161. *Lovén*, 1883, *Pourtalesia*, pp. 60, 76.

The test is moderate in size, circular in outline at the ambitus, rather flat and depending posteriorly actinally, tumid above, being highest and sloping roundly and sharply posteriorly and gradually in front, nearly hemispherical in outline at the sides and over the top. The apex of the test is far back, and there is the apical system.

Apical system with three perforated basal plates and a large right antero-lateral basal with the madreporite, without a pore for the genital duct, and a small accessory imperforate plate, possibly a posterior basal, placed close to the left posterior basal. The madreporite is restricted to the anterior part of the right anterior basal, which separates the posterior basals and the posterior radials. Radial plates well developed and perforated, their pore being visible from above.

Ambulacra similar, apetalous, flush, with high plates; the anterior is long; the antero-lateral ambulacra are slightly arched, concavity in front, and the posterior are wide and ornamented on either side of the plastron; number of plates small; zones increasing in width to the ambitus and then diminishing to the peristome. Pores solitary. Tubercles in the ambulacra small and from one to four to a plate with miliaries.

Interradia wide, especially the anterior, with but few plates, and these are high and carry several tubercles, which increase in number and size actinally.

Peristome excentric in front, semilunar, with a broad, long, posterior labrum. Large pedicels around the mouth. The sternum is low, and with a true plastron (amphisternous) on which the tubercles are slightly crowded. There is a slight posterior actinal keel. The periproct is small, posterior, and either close above the ambitus or at a little distance from it, and superior to a projection.

The spines are small, straight, cylindrical, and largest actinally; all are short and delicate. There are no fascioles.

Recent. Antarctic Ocean, from 1950 fathoms.

A. Agassiz remarks that the shape of the test varies, and some young forms are conical; but with age the test is more depressed and the keel becomes prominent, whilst the periproct gets nearer the ambitus.

The colour varies from violet to a dirty green.

The ambulacra of this genus are narrow in relation to the interradia, and in both areas there is a remarkable paucity of plates, and as the apex is far back the anterior ambulacrum is long, and the anterior interradia are large.

The ambulacral pores are shown to be single in the drawing given by Lovén in 'Pourtalesia,' p. 76, and it is evident that there is some variability in the structure of the apical system (see A. Agassiz, Report on 'Challenger' Echini, pl. xxxv *a*).

A. Agassiz considers that *Genicopatagus* has striking affinities with *Holaster*, *Cardiaster*, and *Toxaster*. He notices that the ambulacra in *Genicopatagus* are slightly sunken as in *Toxaster*, that their structure is that of *Cardiaster*, and that the outline of the test recalls that of *Holaster*. He shows that the genus differs from *Palæopneustes*. He considers that the apical system is more like that of *Cardiaster*, not being so elongate as in

Holaster. The flat actinal surface and the globular outline remind that author of *Cardiaster*, but the actinostome is more central than in *Cardiaster*.

Lovén, 'Pourtalesia,' p. 60, notices that *Genicopatagus*, in common with the other abyssal genera, is apetalous; the ambulacra are flush with the test, and only contract up to the top. The plates are few, as high as they are broad, or nearly so, are regularly hexagonal; the pores are very minute, and placed centrally or subcentrally, and the pedicels are small and simple. The description given by Lovén (p. 76) of the apical system of *Genicopatagus affinis*, A. Ag., we have taken to be generic in preference to the delineation and description given in the 'Challenger' Report, for it is probable that the specimen therein described was imperfect.

Genus PALÆOBRISSUS, *A. Agassiz*, 1883, *Report on 'Blake' Exped. Ech., Mem. Mus. Comp. Zoöl. Harv.* vol. x. no. 1, p. 56, pl. xxiv.

Test moderate in size, ovoid in marginal outline, widest anteriorly; narrow and truncated posteriorly; tumid but depressed dorsally, more or less flat actinally, projecting downwards posteriorly.

Apical system excentric in front, at the vertex, small, compact; four basal plates in contact; the genital pores small in the anterior pair and large in the posterior basal plates; radial plates small.

Ambulacra diverse, flush, apetalous; the anterior with small distant pairs of pores; the paired ambulacra widely open at the ambitus, increasing in breadth from the apex, the pairs wide apart, few, the pores large and circular, remote from the apex, actinally in peripodia.

Interradia with numerous plates, with distant primary tubercles, small and of uniform size, but increasing towards the ambitus; miliaries between; primary tubercles closer actinally, but the ambulacra are bare.

Peristome semilunar, excentric in front, labrum projecting; an amphisternum. Periproct circular, low down in the posterior truncation. Tentacles of the abactinal pores broad, flat, and with small disks, the actinals fimbriated.

Primary spines small, slender, straight; miliary spines one third of the length of the others; short-stemmed, stout-headed

and large-headed tridactyle pedicellariæ on the ambulacra; scattered upon the test irregularly are long-stemmed, large, slender, open-headed tridactyle pedicellariæ.

Recent. Caribbean Sea, Barbados, 82–185 fathoms.

Section *Prymnadetes.* (Subanal fasciole absent; peripetalous fasciole present.)

Genus ACESTE, *Wyv. Thomson*, 1877, *Voyage of the 'Challenger,' Atlantic*, vol. i. p. 376, figs. 95, 96. *A. Agassiz*, 1881, *Report 'Challenger' Echini*, p. 195, pls. xxxii. & xxxiii *a*. *Lovén*, 1883, *Pourtalesia*, pp. 53, 88, pl. xx.

Test small and moderate in size, long, low, narrow, and ovoid or obcordate in marginal outline, broadest anteriorly, where there is a large deep groove dorsally; narrowest posteriorly, and more or less vertically or obliquely truncated there; test rising gradually from the anterior part to the posterior, gibbous vertex; tumid and broadest near the dorsum, narrow actinally; the broad abactinal groove extending far back from the anterior notch.

Apical system very excentric posteriorly, placed at the vertex, small; two basal plates, each with a large genital pore; the madreporite small, and either between the plates or in the right anterior basal plate; radial plates small.

Anterior ambulacrum very broad, placed in the anterior groove, commencing far back; the plates very broad, low, numerous; the pores simple near the apex and double along the abactinal groove, single actinally, rows distant. Antero-lateral ambulacra flush and apetalous; long, narrow, with tall, narrow plates; those of the anterior zone are small and uniporous; the plates of the posterior zone biporous. These ambulacra pass along the outside of the anterior groove to the anterior third of the test and then over the flanks to the peristome, and they are directed almost transversely abactinally. Postero-lateral ambulacra broader than the antero-lateral; plates high and narrow abactinally, flush, apetalous, and uniporous; actinally the plates are large and long.

Interradia: the antero-lateral narrow, the postero-lateral broader, and with the plates 2 and 3 of zone *a* of the right area united actinally.

Peristome quite anterior, vertical, at the anterior and actinal end of the groove, elliptical or subpentagonal, with a plated membrane, the largest plates towards the outer part; mouth

subcentral; the anterior margin formed by broad ambulacral plates; peristomial interradial plates very narrow; the labrum narrow, long, projecting slightly; a true amphisternum, which is large and prominent. Phyllodian pedicels with a double marginal series of circumferential filaments and a central five-partite bulge.

The ornamentation is small and miliary within the great groove; small primary tubercles at the edge, larger beyond the fasciole, and increasing to and over the margin of the test, crowded on the sternum, usually several tubercles on a plate; ambulacra bare actinally. A peripetalous fasciole close to the sides of the groove abactinally, crossing it in front and passing over the test between the apical system and the posterior extremity, and crossing the lateral ambulacra not far from the apical system, and not interfering with the continuity of the pores.

Periproct in the posterior truncation, circular, with numerous concentric anal plates. Spines short, some larger and spathiform, crowded on either side of the abactinal groove and upon the sternum, those surrounding the periproct long, bent, and pointed; other spines smaller and curved. Some minute mushroom-shaped spines in the anterior groove. Large tentacles within the fasciole and in the anterior ambulacra, with huge disks, furnished with very numerous radiating, narrow, pointed supports in a circle.

Recent. Sandwich Islands to Low Archipelago, Buenos Ayres to Tristan da Cunha, Canaries; 600–1900 to 2600 fathoms.

The genus *Aërope* had a somewhat remarkable origin. The 'Challenger' Expedition started at the close of the year 1872, and whilst in the Bay of Biscay, in that year, according to the Report on the 'Challenger' Echini by A. Agassiz, 1881, p. 194, a species of the genus was dredged, and a similar form was got from the coast of Portugal in 1873. Nothing was heard of the extraordinary form, and no notice was published of it, until Sir Wyville Thomson in 1877 described other specimens, which were dredged in May 1873 between Bermuda and 130 miles S.E. of Sandy Hook. These specimens were described in Sir Wyville Thomson's unofficial work, 'Voyage of the Challenger,' Atlantic, i. p. 380, fig. 99 (1877). The description given is of a species, not of the genus.

In 1875 the 'Valorous' sailed with the late Dr. J. Gwyn Jeffreys and Mr. (now Dr.) Herbert Carpenter, and in a deep

dredging in Davis's Straits an unknown Echinoderm was got. This form, with a great number of Invertebrata, was confided to the Rev. A. Norman for description. In June 1876 Mr. Norman's report was read before the Royal Society, as forming part of that of the director of the Expedition (Proc. Roy. Soc. xxv. pp. 202–215, June 1876). The notice is excellent, and it is stated before the description, "a remarkable new genus of Echinoidea occurred here." On p. 212 it is written, "This new and most interesting form will be named *Aërope rostrata* by Sir W. Thomson;" and there is a footnote, "When this description was read I had suggested a name for the present species; but having since learnt from Sir W. Thomson that it has also been procured in the 'Challenger' Expedition, I gladly adopt the above name under which I found that he was about to describe it." The 'Challenger' returned in May 1876.

Sir Wyville Thomson handed over the Echini of the 'Challenger' to their able describer A. Agassiz in 1876, who published a differential and critical definition of the genus *Aërope* in the official report, 1881.

He left Mr. Norman out of the matter, and his references to the Royal Society's Proceedings by mistake relate to Sir W. Thomson instead of Mr. Norman. A. Agassiz wrote, 'Challenger' Report, p. 190, that the genus was first described by Sir W. Thomson in the Voyage of the 'Challenger,' vol. ii. p. 28 (correct reference vol. i. p. 380). There is no doubt that A. Agassiz had not had the opportunity of knowing that Mr. Norman's description was the best and earliest.

Genus AËROPE (described without a name, 1876, *A. Norman*, *Proc. Royal Soc.* 1876, p. 211), *Wyv. Thomson*, 1877, *Voyage of the 'Challenger,' Atlantic*, vol. i. p. 380, fig. 90. *A. Agassiz*, 1881, *Report on the 'Challenger' Echini*, p. 190, pls. xxxiii., xxxiii *a*.

Test small to rather large, rather stout, very elongate, generally cylindrical, higher than broad, oval and acuminate posteriorly, slightly rounded in front in marginal outline, and sloping anteriorly, highest centrally, and convex actinally behind the peristome.

Apical system excentric in front, within the anterior slope, with four basal plates, perforated, the ducts ending in as many tubes; madreporite in the right anterior plate extending to the centre; antero-lateral radial plates small, and separating the

lateral basal plates, but not uniting centrally in consequence of the madreporite.

Anterior ambulacrum in the front part of the depression, larger than the others; its rows of pairs of pores far apart and the pores larger than those of the other ambulacra. The antero-lateral divergent, and the postero-lateral passing back at a small angle and very long; both narrow, flush, apetalous, with small plates, each with a pair of pores above the ambitus, and with large pores in peripodia around the peristome; the plates of the posterior pair very long actinally on either side of the sternum; pairs of pores very few in number.

Interradia with very much larger plates than the ambulacra, the postero-lateral very broad, a long narrow peristomial plate in front of a true and more or less keeled amphisternum; other peristomial plates narrow.

Peristome excentric in front, circular, with the labrum projecting on a lower level than the opening. Periproct dorsal, flush, and elliptical, pointed forwards, somewhat remote from the posterior end of the test; membrane with concentric plates.

Tubercles small, somewhat numerous on the abactinal interradial plates, one on each ambulacral plate dorsally, largest on the sternum.

A broad fasciole extending obliquely from close behind the vertex, which is subcentral, around the edges of the anterior depression and curving actinally close to the anterior margin, crossing the ambulacra and including a broadly elliptical space; apparently the pores of the paired ambulacra are uniporous below the fasciole.

A few very large disciferous tentacles in two rows in the anterior ambulacrum; and some large penicillate tentacles around the peristome. Spines, some club-shaped, the others acuminate cylindrical; the first kind commonest actinally and behind the fasciole, spathiform and large upon the sternum, hollow, longitudinally ridged.

Recent. Davis Straits, Bay of Biscay, coast of Portugal, E. coast of U. States, 130 miles from Sandy Hook, Arafura Sea. 800 to 1750 fathoms.

In the beautiful drawing given in the 'Challenger' Report, pl. xxxiii *a*. fig. 10, there is a possibility of the existence of a fifth imperforate basal plate. It is very important that separate descriptions of the specimens from Davis Straits and the remote Arafura Sea should be presented to science.

Section *Pyrmnodesmia.*

(A subanal fasciole, others may be present.)

Genus Ovulaster, *Cotteau*, 1884, *Bull. Soc. Zool. de France*, vol. ix. p. 328. *Seunes*, 1888, *Bull. Soc. Géol. Fr.* sér. 3, vol. xvi. p. 803.

Test of moderate size, thick, elongate, rounded and slightly enlarged in front, sub-acuminated and truncated behind, slightly keeled above and tumid actinally, very faintly grooved in front.

Apex very excentric in front. Apical system with the four lateral basal plates in contact, the madreporite in the right anterior plate.

Ambulacra dissimilar, flush with the test and apetalous; the anterior narrow, and its pores less apparent than those of the others. Antero-lateral ambulacra very widely divergent, with the poriferous zones arched concavity forwards. All the paired ambulacra are narrow, barely flexuous and very angular at the apex; poriferous zones composed of small pores lodged in fossettes, arranged in close pairs near the apex and much more distant towards the peristome. The pores open quite at the base of the plates, which are tall.

Tubercles abundant, scrobiculate, the intermediate granules homogeneous. The peristome is subcircular, slightly sunken, and very excentric in front; the sternum long and sub-pointed. The periproct is oval, high up, and is near the summit of the posterior surface. A subanal fasciole.

Fossil. Cretaceous: Europe (France).

Genus Palæotropus, *Lovén*, 1872, *Etudes*, p. 17, pls. xii., xiii., & xxxii. *A. Agassiz*, 1881, *Report on Challenger' Echini*, p. 157; 1883, *Report on 'Blake' Echini*, p. 54, pl. xviii. *Lovén*, 1883, *Pourtalesia*, p. 78, fig. 208.

The test is small, has an ovoid contour, is uniformly tumid above, moderately convex below, and is slightly flattened posteriorly, and well rounded at the sides, smooth.

The apical system is slightly excentric in front, consolidated, and more or less pentagonal. The basal plates are fused in a mass, and there are no sutures; the madreporite is indicated by a fissure, or by pores near the position of the right anterior plate. The radial plates are distinct, small, and perforated, and the posterior pair are separated. There are but two generative ducts having their pores at the tops of two large tubular eminences.

The ambulacra are flush with the test, apetalous, and the five or six plates nearest the apex are small, in a single series; lower down and to the peristome there is a double series of ambulacral plates. There is but one pore to a plate except at the peristomial edge, where there are two in some plates. A subcircular subanal fasciole only. The internal plates 6, 7, 8 of the broad bivium are elongate and are within the episternal angle in relation to the fasciole, and plates 7 and 8 have their pores transposed to the episternal side of the suture. Phyllodian tentacles with a single marginal row of filaments. Tubercles small, several on a plate, largest actinally.

Peristome widely open, more or less semilunar, with a small labrum. The second and third plates of zone *a* in the right posterior interradium are fused. An amphisternum, and the episternum is symmetrical and well developed. The periproct is oval, longitudinal, placed towards the middle of the posterior face, and it is comprised within the first five abdominal plates, being separated from the episternum by one double plate only. Oral and periproctal membrane-plates well developed.

Recent. Azores, 250 fms.; Caribbean Sea, 82–242 fms.; between Bermuda and mainland, 233 fms.; Philippines, 375 fms.

The typical species is *P. Josephinæ*, Lovén.

The interesting type of this genus was dredged off the Josephine Bank, and it measured eleven millimetres. It was doubtless immature, and upon the admission of that supposition changes will probably have to be made in the diagnosis. Other specimens of *Palæotropus Josephinæ*, Lovén, have been discovered in the Caribbean Sea; and A. Agassiz wrote upon them in the 'Blake' Expedition, Report on the Echini, p. 53 (1883). A small specimen 10 millim. in length did not differ from that figured by Lovén.

Older specimens measuring 23 millim. in length (plate xxiii.) are comparatively less globular and more flattened, but otherwise do not vary greatly in appearance from the younger specimens.

A. Agassiz remarks that there is little difference in the arrangement of the ambulacral plates in young and old specimens; but he figures the ambulacra of his specimens with double plates near the apex. There are only two generative pores in all the types, and Agassiz remarks on the presence of the basal 5. On comparing the drawings of *Palæotropus Josephinæ* in the 'Blake

Echini,' pl. xxiii., the distinctions between them and those of Lovén seem remarkable. The apex is very excentric in front in the specimens figured by Agassiz, the ambulacra are double near the apex, the apical system is longest transversely, and the fifth basal is visible. The shape of the mouth and of the anus, the visibility of the pentagonal fasciole from below, and indeed the shape of the test as a whole differ in the two forms. These are startling differences to find in the same species.

Agassiz mentions *Palæotropus Thomsoni*, and the diagnosis he gives ('Blake Echini,' p. 55) shows that the form differs most strikingly from all the other specimens of *Palæotropus*. It is closely covered with uniform tubercles on the abactinal side, and has a proportionally greater number of coronal plates and a high test with a keeled posterior interradium. The apex is more posterior than in *P. Josephinæ*. He remarks that the species "differs most strikingly from all the other species," and refers to the bare posterior lateral ambulacra actinally, the very elongate plastron, and the longitudinally elongate fasciole. No illustration is given of the species, which was dredged from a depth of 233 fathoms between Bermuda and the mainland.

Another species was described by A. Agassiz in the Report on the 'Challenger' Echini, p. 158 (1881). In this, *Palæotropus Loveni*, there are three generative pores and no fifth basal; the mouth, anus, fasciolar space, ornamentation, and the shape differ from those of the original type; moreover there is a wide anterior ambulacral groove drawn on plate xxi. fig. 6. As this form came from the Philippines, a considerable departure from the type was to be expected. Considering the history of *Hemiaster*, it may belong to Lovén's genus.

Genus HOMOLAMPAS, *A. Agassiz*, 1872–74, *Revision of the Echini*, pp. 347, 562; 1881, *Report on the 'Challenger' Echini*, p. 163; 1883, *Report on 'Blake' Echini*, p. 87.

Syn. *Lissonotus*, A. Ag., 1869.

Test large, elongate, cordiform, notched at the anterior margin considerably, and less so posteriorly; depressed, longer than broad, broader than high, and broadest and highest in the anterior third. Very flat actinally, but with a keel in the median line of the plastron. Highest anteriorly, where it is boldly curved and precipitous, and sloping gradually posteriorly to the short truncation. A broad anterior groove.

Apical system very excentric in front, with four perforated basal plates; the madreporite large, in the usual basal, separating the lateral basals and the posterior radial plates and extending backwards. Radial plates small and distant.

Ambulacra apetalous, uniporous; the anterior ambulacrum is in the anterior groove; the lateral ambulacra are widely separated, somewhat waved, widen from the apical system to the ambitus, and thence they become narrow to the peristome. The postero-lateral are very long. The plates are rather high, and the pores are in simple series. The interradia are broad and have large plates. The peristome is semilunar, with more or less rounded angles. There is a thin labrum.

The plastron is amphisternous, is covered with a tubercular ornamentation, and is bounded laterally by the broad and comparatively bare actinal plates of the posterior lateral ambulacra. The periproct is small and oval, longest nearly vertically, and situate in the posterior face close above the margin.

The ornamentation of the interradia abactinally is of a few large primary tubercles much larger than any others, and there are secondary tubercles and miliaries in abundance. Actinally the primaries are smaller, are surrounded by a sunken scrobicule, and this is also seen from within the test as a sunken "purse," as in *Lovenia*. The spines of the large tubercles are gigantic and curved, and those of the smaller tubercles are small and curved; those of the actinal side are spathiform. There is a subanal fasciole, which is broad and pentangular, pointed downwards and with indistinct anal branches. The peripetalous fasciole is inconstant, thin, and incomplete.

Recent. Straits of Florida, 734–1920 fms.; coast of Brazil, 32–400 fms; and Pacific, Sandwich Islands to Low Archipelago, 2425–2475 fms.

There are two species. The type was an immature form.

Genus Argopatagus, *A. Agassiz*, 1881, *Report on the 'Challenger' Echini*, p. 160.

Test of moderate size, very thin and transparent, truncated in front and bluntly pointed behind, ovoid in marginal outline; depressed abactinally, flat actinally; broadest in the anterior two thirds, narrower posteriorly.

Apical system slightly posterior, corresponding with the summit, with four perforated basal plates; and the madreporite is in the right anterior, and passes backwards, separating the posterior basals; basal sutures obliterated.

Ambulacra flush with the test, uniporous, increasing in width to the ambitus and apetaloid, with but few plates, which are large, high, and hexagonal. The areas diminish in breadth to the peristome. The anterior ambulacrum appears to resemble the others.

The interradia have large plates and but few of them.

Peristome excentric in front, broad, but short longitudinally, more or less semilunar, and with a well-marked posterior lip which projects. Plastron well developed, amphisternous and tuberculate, contrasting with the broad plain posterior ambulacra on either side. Periproct supramarginal, circular in outline. There is a subanal fasciole only.

Tubercles of the primary kind largest and most crowded at the ambitus in all the areas, scattered over the test above the ambitus, absent near the apex, and regularly placed in the odd ambulacrum. Spines of actinal surface slender, club-shaped and hollow, with a thick shaft. Ambulacral pedicels most powerful and with small disks near the apex, and diminishing actinally. Tufted pedicels around the peristome.

Recent. (One species) Arafura Sea, 800 fms.

Genus Cleistechinus, *P. de Loriol*, 1882, *Descript. des Echinides des Environs de Camerino, Mém. Soc. Phys. et Hist. Nat. de Genève*, t. xxviii. no. 3, p. 27.

The test is small, thin, depressed, tumid dorsally, oval, elongate, rounded in front, where there is no notch, low and truncated behind.

Apical system probably disconnected; the system is excentric in front, and the only specimen observed has two genital pores relatively large and very close.

The ambulacra are composed of extremely small pores, barely visible here and there. It is impossible to affirm whether the pores are single or in pairs. Ambulacral plates relatively very large, so that there are almost as many ambulacral as interradial plates. There is no anterior groove.

The peristome has a posterior, projecting lip. The periproct is oval, elongate, open at the summit of the posterior surface.

The tubercles are very unequal, some being much larger than others, and few and far between.

Fossil. Miocene: Europe.

It is stated in the description of the solitary species that the plastron is slightly hollowed out around the peristome, which has a very projecting lip. The ambulacra are indistinct, and it appears from the figures that they are flush with the test and not petaloid.

De Loriol places the form near *Argopatagus*, A. Agass., but notices that he cannot state anything about the presence of fascioles.

The combination of the peculiar ambulacra and the pair of close, probably disunited, generative plates (basals) with a projecting lip are dwelt upon by the careful naturalist to whom we owe the genus.

III. Family Leskiidæ, Gray.

Test thin, ovoid. Apical system with three basal plates fused into one, two large genital pores only and upon conical prominences. Peristome excentric in front, pentagonal, with five angular buccal plates. Periproct circular, and with from five to seven plates. A peripetalous fasciole.

Genus *Palæostoma.*

Gray founded the genus *Leskia* in 1851, the name being already employed in Natural History. Subsequently Lovén in 1867 diagnosed the genus *Palæostoma*, which is identical with *Leskia*. Gray distinguished the generic characters.

Genus Palæostoma, *Lovén*, 1867, *Öfvers. Kongl. Svensk. Vetensk.-Akad. Förhandl.* no. 5, p. 432; 1874, *Études*, p. 50, figs. 39, 197–199; 1883, *Pourtalesia*, p. 79, pl. xvi.

Syn. *Leskia*, Gray, 1851, Ann. & Mag. Nat. Hist., and 1855, Cat. Rec. Ech. Brit. Mus. pt. i. p. 63.

Test thin, moderate in size, ovoid, broadest behind the centre and anteriorly, more or less narrow posteriorly, tall and subglobose abactinally, highest behind, convex actinally, anterior groove slight.

Apical system subcentral, small, three of the basal plates fused

into one; two large genital pores upon conical protuberances. Madreporite indistinct. Radial plates small, separate.

Ambulacra dissimilar, sunken, the anterior in a slight abactinal groove, the plates rather high; the pairs of small pores vertical and in two rows. Petaloid part of the antero-lateral ambulacra divergent, broad, poriferous zones broad; postero-lateral petals shorter. The plates beyond the petals broad with single pores, but narrowing greatly at the peristome; the postero-lateral areas wide on either side of the sternum, the fifth plate of the inner zone of the right posterior ambulacrum actinally pushing into the line of the posterior interradium. Phyllodian tentacles with a central protuberance and marginal filaments. Frontal tentacles with a calcareous disk and rays. Primary tubercles perforated and crenulate, numerous on the large interradial plates.

Interradia with few plates; both the antero-lateral areas with the second plates of both their zones beyond the peristomial plate united, the same union occurs in the left postero-lateral interradium. In the right postero-lateral interradium there is union of the second plates of both zones with the third plate of zone "*b*." The peristomial plate of the odd interradium is long; the sternum is not quite symmetrical, the second plate of zone "*b*" being short; the episternal plates are not parallel.

Peristome excentric in front, nearly flush, pentagonal, the greater part of the margins formed by interradial plates, the ambulacra forming the angles and very small; five triangular buccal plates. Periproct circular, near the upper extremity of the rounded posterior surface, 5–7 triangular plates on its membrane. A sinuous peripetalous fasciole. Spines and tubercles subequal, the former subulate and largest dorsally.

Recent. China, East Indian Islands.

IV. Family POURTALESIIDÆ,

(Pourtalesiadæ) *Lovén*, 1883, *Kongl. Svensk. Vet.-Akad. Handl.* Bd. xix. no. 7, p. 82 (Pourtalesia).

Syn. Subfamily *Pourtalesiæ*, Wyv. Thoms. & A. Agass. (pars).

Test very elongate, subcylindrical or obconical, truncated anteriorly and broad there, tumid in the middle and rostrated or pointed posteriorly; convex or humped dorsally, flat actinally.

A deep anterior recess with the peristome vertical and at its lowest part. The periproct superior to the projecting posterior rostrum, or when there is no rostrum, placed actinally. Apical system variable, compact or disconnected. Ambulacra flush, apetalous, may be disconnected or discontinuous; pores single or slit-like. Tentacles homoiopodous. Interradia forming, or not, a continuous vertical band in the postero-lateral areas; sternum distinct or not. Spheridia absent in the anterior ambulacrum and exposed and numerous in the others. A subanal fasciole may or may not exist, but is not accompanied by modification of the ambulacral plates. Spines short, straight or curved, only crowded on the sternum.

Genus *Pourtalesia.*
Spatagocystis.
Echinocrepis.

The genus *Pourtalesia*, A. Agassiz, is one of the most interesting, and its affinities have given much trouble to the three distinguished naturalists to whom we owe the knowledge of the morphology of the species. The first species, *P. miranda*, which was used as the type of the genus by A. Agassiz, was dredged by the late M. de Pourtales off Florida, at a depth of 349 fathoms, and it was described by A. Agassiz, 1869, in Bull. Mus. Comp. Zoöl. i. p. 272. Subsequently the genus and the same species, *P. miranda*, were described in the 'Revision of the Echini,' 1872–74, p. 344, pl. xviii. The dredgings of H.M.S. 'Porcupine' yielded two other species, which were described by the late Sir Wyville Thomson in Phil. Trans. 1874, p. 747, pls. lxx. and lxxi. These species, *P. Jeffreysi* and *P. phiale* (*P. phyale*, W. T.), were got—the first-named from 317 fathoms between Färoe and Shetland, and the latter from 1215 fathoms in the Rockall Channel. An excellent general description of *P. Jeffreysi* and a very good engraving were published by the same author in his work called 'The Depths of the Sea,' 1873, p. 108.

The dredgings of the 'Challenger' in the Pacific produced no less than five new species, and they were described and figured in the Report on the Echinoidea by A. Agassiz, 1881, p. 132 —*P. carinata*, *P. hispida*, *P. laguncula*, *P. ceratopyga*, and *P. rosea*. The genus has its principal quarters in the Pacific Ocean, where there are five species; and there are three species in the Atlantic, viz. *P. Jeffreysi*, *P. phiale*, and *P. miranda*. These are

all dwellers in very deep water, and indeed *P. Jeffreysi* is the only species with a moderate bathymetrical distribution.

In 1883 Prof. Sven Lovén published his great work on "*Pourtalesia*, a Genus of Echinoidea" (Kongl. Svenska Vetenskaps-Akad. Handlingar, Bd. xix.), and he had obtained specimens from the Survey of the N. Atlantic by the steamer 'Vöringen' and from A. Agassiz and Sir Wyv. Thomson. He especially investigated *P. Jeffreysi*.

The descriptions of what Lovén very truthfully called "the most extraordinary Echinoid hitherto known," by the authors alluded to, are models of plain exactitude, and those of Sir Wyville Thomson are in his best style. There is, however, considerable diversity of opinion amongst the three naturalists regarding the alliances of the genus with extinct forms; but now that it can be said that the morphology of one of the species has been described with wonderful accuracy by Lovén, the palæontologist may pass his opinion on the subject.

There is a difficulty in associating all the species now classified under *Pourtalesia* in one genus, which has been felt by Agassiz and Lovén, and will interest the advanced students of the Echinoidea.

Can *Pourtalesia ceratopyga*, *P. Jeffreysi*, *P. rosea*, and *P. miranda*, for instance, be placed in the same genus? A. Agassiz notices that he was disposed to divide the recognized species; but on the examination of the whole group he determined to let them remain under one head. The propriety of this is a matter for discussion on ordinary zoological principles. It must be remembered that Lovén has shown that there are morphological differences between some of the eight species which he recognizes to belong to *Pourtalesia*, which are without example in any other genus. Yet it seems to be impossible, in his opinion, to break up the genus in order to meet the variability of important structures. In fact he considers that the species seem to be undergoing evolution of a remarkable kind.

There are species now included in the genus (*P. ceratopyga*, *P. Jeffreysi*) which have disconnected apical systems, and others (*P. rosea*, *P. miranda*) which have them compact; and in the first group the postero-lateral interradia are in contact actinally and abactinally in most of the species, but in one the contact is abactinal only; in the other group there is not this contact. Yet the structural affinities of the two groups are otherwise so

close that the great differences in the structure of the apical systems and in the interradial areas seem anomalous. There is some variation in the size, position, and suturing of the basals in one of the species with a disconnected bivium, but there have been no specimens discovered in which any approach to a blending of the two types of apical system has been seen.

There is, moreover, a difficulty in deciding, if a division is to take place, to which of the groups the name *Pourtalesia* should belong, for *Pourtalesia miranda*, A. Agassiz, was the first species described, and the nature of its apical system and the development of its postero-lateral interradia do not appear to coincide with *P. Jeffreysi*, Wyv. Thoms., and its allies.

In describing *P. miranda*, A. Agassiz wrote (Revision, p. 345) as follows:—"The posterior pair of ambulacra extend on both the sides of an elongated plastron to the base of the snout-like prolongation, where they curve sharply upwards, and run close on the abactinal part of the test to the abactinal system situated almost at the summit of the nearly vertical anterior extremity, along a well-marked wedge-shaped ridge extending from the apical system into the rostrum protecting the anus." Again, on p. 346, "The abactinal system, consisting of four large genital openings placed close together, with the madreporic body tolerably well defined in the centre, is situated at the origin of the anterior groove."

On plate xviii., Revision of the Echini, fig. 1, a side view of *P. miranda* shows the postero-lateral ambulacrum of the left side, passing forwards abactinally to the very front of the test. It is also evident in fig. 2 that the postero-lateral ambulacra pass from the peristome on either side of the sternum far back, and that each is continuous. In fig. 3 the apical system is shown to be very excentric in front, and the postero-lateral ambulacra reach it; there is no junction of interradial plates between the apical system and the bivium. Fig. 9 on the same plate shows most distinctly that the apical system is compact, and that the antero-lateral ambulacra do not terminate in radials which separate the anterior and posterior basals, as in *Echinocorys*.

But in the classification *P. miranda* was placed by A. Agassiz amongst the Ananchytidæ (*op. cit.* p. 344); and in his definition of that group he states, "the apical system more or less elongate, but not disconnected." The difficulty of associating the forms

of *Pourtalesia* with the Ananchytidæ was, however, subsequently noticed by the same naturalist; and in his great work on the 'Challenger' Echini, p. 124, he followed Sir Wyv. Thomson and placed them in a subfamily "Pourtalesiæ" of the family Spatangidæ. Nevertheless A. Agassiz did not consider that the compact apical system of his type, *P. miranda*, militated against the admission of other species with disconnected apical systems into the genus *Pourtalesia*. In fact he appears to discredit the taxonomic value hitherto placed upon the different apical arrangements—compact, elongate, and disconnected. He states (p. 133), "It is remarkable how great is the variation in the extent of the separation of the bivium and trivium at the apical system in the different species of the genus;" and, in describing *P. rosea*, he remarked ('Challenger' Report, p. 141):—"This species is also remarkable for not having, as in other species of the genus, its apical system divided by the encroachment of the postero-lateral ambulacra into a bivium and trivium."

It appears that the existence of compact and disconnected apical systems with the correlative interradial arrangements in one family must be admitted to be consonant with Zoology. Their occurrence in the same genus cannot be maintained, except under most unusual conditions.

It is indeed highly fortunate that the genera *Echinocrepis* and *Spatagocystis*, which have been so carefully described by A. Agassiz and Lovén, should have been discovered, for they let a flood of light into the classification of the species included in *Pourtalesia*. They will be considered further on, but it is advisable to state now that *Spatagocystis* is in alliance with the species of *Pourtalesia* which have disconnected apical systems; and that *Echinocrepis* is allied to *P. miranda* and *P. rosea* with compact apical systems.

The definitions of the genus *Pourtalesia* will be found in the 'Revision of the Echini,' and in the Report on the 'Challenger' Echinoidea; and one was published by Sir Wyville Thomson in the 'Phil. Trans.' The descriptions by Agassiz are positive and also very comparative.

The morphology has especially been studied by Lovén, and published in 'Pourtalesia.' The following definition has been collected from the works of these authors.

Genus POURTALESIA, *A. Agassiz*, 1869, *Bull. Mus. Comp. Zoöl.* i. p. 272; 1872–4, *Revision*, p. 344. *Wyville Thomson*, 1874, *Phil. Trans. Roy. Soc.* vol. clxiv. pt. 2, p. 747. *Lovén*, 1883, *Pourtalesia*, p. 82.

Test small or rather large, thin or moderately thick, long, flask-shaped, with a deep inversion of the anterior face, at the lower part of which is the peristome; with a rostrum produced posteriorly and inferiorly, the periproct being above the rostrum. Test subcircular or broadly expanded in front profile, or generally tumid at the sides, flatter actinally, and slightly depressed abactinally.

Apical system very excentric in front, disjunct, with four basal plates perforated by the genital ducts; sutures fused; madreporite in the right anterior, and often between or in the other basals; anterior and antero-lateral radial plates aborted more or less; postero-lateral radials separated by some plates of the odd interradium and disconnected from the basals by plates of the postero-lateral and odd interradia.

Ambulacra apetalous, uniporous, with large wide plates; the anterior large, deeply inverted, forming the peristomial upper margin; antero-lateral flush, placed far forward, nearly transverse; postero-lateral flush, very long, may become discontinuous actinally by the interposition of plates of the postero-lateral interradia; the antero- and a disconnected part of the postero-lateral ambulacra from the lower margin of the peristome, or the antero-lateral may be crowded out.

Interradia with unequal, mostly large, plates; the antero-lateral with a narrow, tall, peristomial plate in one zone (*b*) and a small plate in zone *a*, which may not enter the margin; the postero-lateral meeting abactinally at the median line, and also actinally, or only abactinally, not entering the peristome; the second and third plates of zone *b* of the right postero-lateral area united; the posterior interradium touching or not the peristome, discontinuous or continuous, amphisternous.

Peristome anterior, more or less vertical, at the bottom of the anterior inversion. Periproct above the rostrum. A subanal fasciole around the posterior rostrum. Pedicels similar, pointed, without disks. Spheridia uncovered, numerous, in the lateral ambulacra only. Spines short, slender, fenestrated, often spatulate

or clubbed. Pedicellariæ, some trifid, with circular tops with milled edges.

Recent. Atlantic, Pacific, and Antarctic Oceans; 345 to 2900 fms.

This diagnosis will embrace the following species :—*Pourtalesia Jeffreysi*, Wyv. Thoms., *P. lagunculа*, A. Agassiz, *P. hispida*, A. Agassiz, *P. phiale*, Wyv. Thoms., *P. ceratopyga*, A. Agassiz, *P. carinata*, A. Agassiz.

Of these the last two have the sternum connected and the interradia 1 and 4 do not unite at the median line actinally, but only abactinally.

The diagnosis will not admit *Pourtalesia miranda* or *P. rosea*, A. Agassiz, which have a compact apical system and the postero-lateral interradia separated dorsally. These species should belong to another genus; but as the morphology is as yet unsatisfactory, it is best to place them provisionally in a division of *Pourtalesia*.

Although the diagnosis of *Pourtalesia* just given, will suffice to distinguish it from any other genus, there are some points in the morphology of some of its species which should be recorded, for they are of especial value in showing the aberrant character of the group, how it may be associated, in a family, with other genera, and how slightly it is allied, structurally, to any ancient forms.

Lovén has shown that the inversion of the anterior part of the test not only affects the anterior ambulacrum, but also the peristome and the first plate of the odd interradium. Each side of the peristome, which is narrow and elongate from below upwards, is formed by a narrow and long plate of zone *a* of the antero-lateral interradium. The first plate of zone *b* may enter, so that there is not a "single" peristomial plate; the upper margin is formed of the anterior ambulacral plates. The marginal plates of the lateral ambulacra and the small lip of the posterior, odd, interradium are raised vertically to the actinal plane of the test, so that the mouth is entirely within the inversion. In *P. Jeffreysi* the great height of the first plates of the zones (*a*) of the antero-lateral interradia prevents the antero-lateral ambulacra from entering the peristomial margin.

The interradia 1 and 4 in most of the species are large and form a belt round the test, and it is evident, from Lovén's work, that they do not enter into the composition of the peristome, and indeed are remotely posterior to it.

The large plates of these interradia are very striking, and it has been explained by Lovén, *op. cit.* p. 14, that the heteronomy

of the right posterior interradium is from the union of the second and third plates of zone "*b*." This is unusual amongst the Spatangoidea.

In *P. Jeffreysi* the labrum is very small and is separated from the sternum by the disjunct, first plates of the postero-lateral ambulacra and by the first plates of the anterior zones of the postero-lateral interradia. The sternum is large, is composed of one plate, and is followed by an episternum which is composed of two plates placed side by side and crossed by the fasciole. The periproct is longest transversely, and is surrounded by the 7–9 plates of the posterior interradium, its membrane is more or less divided transversely and covered with small scales.

In *P. Jeffreysi* the first plates of the postero-lateral ambulacra are interposed between the first plates of the antero-lateral ambulacra actinally. Abactinally the last plates of the posterior interradium are separated and intercalated amongst the abactinal plates of the postero-lateral interradia. The true mouth-opening is a slit in a membrane without plates, and the direction is vertical. Some large pedicels are on the posterior ambulacra at the peristomial end, but elsewhere all the tentacles or pedicels are pointed and not prehensile; probably they are all branchial. In *P. laguncula* the labrum is large and long, but barely separates the first plates of the postero-lateral ambulacra, and this also occurs in *P. carinata* and *P. ceratopyga*. The large and numerous spheridia are exposed and are restricted to the lateral ambulacra.

Genus Spatagocystis, *A. Agassiz*, 1879, *Proc. Amer. Acad.* vol. xiv. p. 206; 1881, *Report on 'Challenger' Echini*, p. 140. *Lovén*, 1883, *Pourtalesia*, p. 82.

Test moderate in size, long, low, ovoid, thin, very slightly incurved anteriorly, and with a short, small and narrow beak posteriorly; actinally with a downward projecting keel extending from the anterior groove to the beak; abactinally convex, tumid in front, and lower and narrow behind.

Apical system disconnected, part excentric in front; the four basals connected; three genital perforations, and the madreporite in the right anterior basal. The postero-lateral radial plates separated from the basals by several interradial plates.

Ambulacra apetalous, uniporous; plates varying in width in the different ambulacra, hexagonal.

Posterior interradium with a labrum separated from the amphisternum; postero-lateral interradia meeting abactinally and also actinally. Anterior groove deep and narrow near the actinal margin, not above; peristome in the bottom of the groove. Periproct in a shallow pouch above the short beak and below the overhanging posterior part of the test. Fasciole absent.

Recent. South Pacific; 1600–1950 fms.

Genus ECHINOCREPIS, *A. Agassiz,* 1879, *Proc. Amer. Acad.* vol. xiv. p. 206; 1881, *Report on 'Challenger' Echini,* p. 143. *Lovén,* 1883, *Pourtalesia,* p. 82.

Test large, long, subpyramidal, broadest anteriorly, pointed behind; apex excentric in front. Marginal outline irregularly triangular, nipped in at the sides, with rounded angles; margin tumid, with a groove in the anterior part, which is deep and narrow actinally. Actinally flat, with a keel from the end of the anterior groove to the periproct, which is submarginal. Abactinally steep in front and sloping gradually posteriorly; a broad long keel passing backwards and overhanging the periproct. Plates of the test usually large, hexagonal.

Apical system excentric in front, at the vertex, compact, with four basal plates, three perforated by genital ducts; and the madreporite in the right anterior and extending more or less into the other basals; sutures obliterated. The anterior and antero-lateral radial plates aborted; the postero-lateral small and in contact behind the postero-lateral basals.

Ambulacra apetalous, uniporous, flush except where the anterior is in the groove.

The postero-lateral and posterior interradia not reaching the peristome; the long labrum continuous with the sternum and also not entering the peristomial margin; postero-lateral areas neither uniting dorsally nor actinally. Tentacles homoiopodous.

Peristome at the bottom of the anterior groove actinally; the margin formed by the anterior ambulacrum, the antero-lateral interradia, and the antero- and postero-lateral ambulacra. Tubercles small and few, one on a plate abactinally, largest on the sternum, much granulation. Spines slender, short and club-ended. Neither a rostrum nor a fasciole.

Recent. South Pacific; 1600 fms.

VIII.

List of Subclasses, Orders, Suborders, Families, Alliances, Divisions, Subfamilies, Genera, and Subgenera. List of Genera removed or synonymous with recognized genera. List of Genera formerly recognized and now considered of subgeneric value. Tables. List of new Genera and Subgenera.
Explanation of terms.

Division APETALA, p. 266.

Section *Adetes*, p. 266.

Genus
Genicopatagus, p. 266.
Palæobrissus, p. 268.

Section *Prymnadetes*, p. 269.

Genus
Aceste, p. 269.
Aërope, p. 271.

Section *Prymnodesmia*, p. 273.

Genus
Ovulaster, p. 273.

Genus
Palæotropus, p. 273.
Homolampas, p. 275.
Argopatagus, p. 276.
Cleistechinus, p. 277.

Family LESKIIDÆ, p. 278.

Genus
Palæostoma, p. 278.

Family POURTALESIIDÆ, p. 279.

Genus
Pourtalesia, p. 284.
Spatagocystis, p. 286.
Echinocrepis, p. 287.

Total genera	255
Subgenera	50
Divisions	6
	311

These include 12 new genera and 7 new subgenera.

The extinct genera are	161		Subgen. 34				
The genera with extinct and existing species ..	41	94	„ 9	16	Divisions 5	6
The genera with recent or existing species only ..	53		„ 7		„ 1	
	255		50		6	

Genera synonymous with recognized types or abolished	108
„ placed as subgenera	42
	150

The following genera have been considered to be superfluous or synonyms of others:—

Genus *Palæocidaris*, *Perischocidaris*, *Echinocrinus*, *Protoechinus*, *Typhlechinus*, *Melechinus*, *Xenocidaris* (spines only), *Cystocidaris*, *Palæodiscus*.

Genus *Rhabdocidaris*, *Leiocidaris*, *Dorocidaris*, *Stephanocidaris*, *Phyllacanthus*, *Porocidaris*. (These are now divisions of *Cidaris*.)

Genus *Discocidaris*, *Anaulocidaris*, *Schleinitzia*, *Eocidaris*.

Genus *Hyposalenia*, *Pseudosalenia*, *Poropeltis*, *Tiaris*, *Hemipygus*, *Pseudodiadema*, *Tetragramma*, *Hebertia*, *Echinodiadema*, Verr., *Trichodiadema*, *Plesiodiadema*, *Loriolia*, *Colpotiara*, *Garelia*, *Savignia*, *Gomphechinus*, *Micropeltis*, *Agarites*, *Pygomma*, *Echinocidaris*, Desm., *Coptechinus*, *Opechinus*, *Heliocidaris*, *Chrysomelon*, *Hipponoe*, *Heliechinus*.

Genus *Mortonia* (Gray), *Rumphia*, *Peronella*, *Polyaster*, *Michelinia*, *Amphiope*, *Lobophora*, *Galerites*, *Trematopygus*, *Parapygus*, *Oolopygus*, *Anthobrissus*, *Clypeolampas*, *Trochalia*, *Asterobrissus*, *Petalaster*, *Cyrthoma*, *Pseudopygaulus*, *Ananchytes*, *Oolaster*, *Stegaster*, *Cibaster*, *Pygopistes*, *Toxaster*, *Heteraster*, *Miotoxaster*, *Globator*.

Genus *Trachyaster*, *Ditremaster*, *Rachiosoma*, *Pliolampas*, *Thegaster*, *Pseudholaster*, *Hypopygurus*, *Atrapus*, *Abatus*, *Desoria*, *Leucaster*, *Tuberaster*, *Plesiaster*, *Opissaster*, *Periaster*, *Perionaster*, *Paraster*, *Anisaster*, *Brissomorpha*, *Heterobrissus*, *Isopneustes*, *Leiopneustes*, *Plagionotus*, *Xanthobrissus*, *Toxobrissus*, *Kleinia*, *Stomaporus*, *Deakia*, *Verbeekia*, *Concophorus*, *Peripneustes*, *Trachypatagus*, *Sarsella*, *Leskia*. *Microsoma* is recorded only.

The following genera are now considered to be of subgeneric value :—

Genus (now subgenus) *Goniocidaris*, *Goniophorus*, *Heterosalenia*, *Hemidiadema*, *Hypodiadema*, *Pseudocidaris*, *Asterocidaris*, *Acropeltis*, *Microdiadema*, *Diademopsis*, *Hemipedina*, *Echinodiadema*, *Pseudopedina*, *Leiosoma*, *Pleurechinus*, *Salmacopsis*, *Psammechinus*, *Evechinus*, *Scutellina*, *Monostychia*, *Echinarachnius*, *Monophora*, *Astriclypeus*, *Nucleopygus*, *Rhynchopygus*, *Hardouinia*, *Pygorhynchus*, *Clypeopygus*, *Oriolampas*, *Jeronia*, *Lampadaster*, *Entomaster*, *Opisopneustes*, *Infulaster*, *Macraster*, *Tripylus*, *Moiropsis*, *Meoma*, *Cyclaster*, *Loncophorus*, *Plesiaster*, and *Macropneustes*.

The following are new genera :—*Eodiadema*, *Placodiadema*= *Plesiodiadema*, Dunc., *Peronia*, *Echinocidaris*, *Goniopneustes*, *Diplothecanthus*, *Plesianthus*, *Lanieria*, *Hagenowia*, *Neopneustes*, *Pseudasterostoma*, *Adelopneustes*, Gauth., *Guettaria*, Gauth.

The following are new subgenera :—*Gagaria*, *Echinites*, non auct., *Mellitella*, *Dochmostoma*, *Oligopodia*, *Studeria*, *Milletia*.

EXPLANATION OF TERMS.

The following explanation of the anatomical terms employed in the classification is intentionally brief, and further information regarding the anatomy of the Echinoidea can be obtained in the Text-books of Zoology and Comparative Anatomy, in 'The Revision of the Echini' and the Report on the 'Challenger' Echini, by A. Agassiz, in Lovén's 'Études sur les Échinoïdées,' in 'Pourtalesia,' and in 'The Echini described by Linnæus,' by the same author, in works by Perrier, Koehler and Ludwig, and by various authors in the Journal of the Linnean Society, the Quarterly Journal of the Geological Society, and the Quart. Journ. Micros. Sci., during the last decade.

The Test.—The individual Echinoid—its covering of calcareous plates and spines, and its internal and external soft structures and organs. The term, when employed in the description of fossil forms, especially refers to the denuded animal, and in the recent forms it is also thus applied; but the shape when the spines remain must be considered, as well as when denuded. The plates of the test are numerous and are in certain regions or systems. The upper surface of a test is *abactinal* or *dorsal*, it has the plates of the *dorso-central* or *apical system* at the apex or elsewhere; the under or opposite surface is *actinal*, and, except in one family, the *peristome* opens out there; the *equatorial* circumference is the *ambitus* or *margin*. There are five *ambulacral* areas, composed of plates reaching in vertical rows from the *Radial* plates of the *Dorso-central* or *Apical system* over the *ambitus* to the *peristome* and sometimes beyond, to the true mouth; and five *interradial* areas, consisting of plates in rows placed between the *ambulacra* and reaching from the *Basal* plates of the *Apical system* to the *peristome* or further. In rare instances, the postero-lateral interradia join abactinally at the median line of the dorsum of the test, and a similar union may occur actinally.

The *peristome* and the *periproct* are at the opposite poles of the test in some Orders of Echinoidea, and such are called *Endocyclica* or *Regulares*. In other orders the *periproct* is beyond the *Dorso-central system* and is somewhere in the median line of the *posterior interradium*, either dorsally or actinally; such forms are called *Exocyclica* or *Irregulares*. The orientation of the Exocyclica is not difficult, the *periproct* indicating the *posterior* region of the test; furthermore, the *madreporite* is, in the majority of cases, in the *right anterior Basal plate* of the *Apical System* and often extends to the centre of the system or posteriorly and even more or less beyond. The orientation of one of the *Endocyclica* is evident when the apical system is preserved, and it may be taken that the madreporite is mainly in the *right antero-lateral Basal plate*. Then the *Radial plate* in front of, or anterior to, and on the left hand of the madreporite-bearing basal is the *anterior Radial plate*, and the ambulacrum associated with it is the *anterior* one. In the event of the loss of the apical system, the determination of the axes of the test may usually be settled by employing Lovén's method (Études, pp. xi *et seq.*).

The margin of the *peristome* formed by *ambulacral* and *interradial plates* has a membranous tissue connected with it and is more or less covered with

plates; this *peristomial membrane* surrounds the *Stoma* or true mouth and is attached to the pyramids of the *Jaws*; but in the edentate kinds, or *Nodostomata*, the inner edge is free. In the *Gnathostomes* the *Jaws* are internal and the *teeth* project free in the *Stoma*. The edge of the peristome may be *grooved* or *incised* or not, and in the first instance *external branchiæ* are present. Within the test, close to the margin of the peristome, are modifications and fusions of the interradial and of the ambulacral plates which, as *ridges* and *processes*, united or not, surround or underlie the *Jaws* and give attachment to their muscles; the structure is the *Perignathic Girdle*, formerly called "*Auricles.*" The ridges are interradial, as in *Cidaris*; the processes are ambulacral. Leading from the gullet within the test, and passing through the *pyramids of the Jaws* and upwards over the inner regions of the ambulacra, are five variably developed finger-shaped organs, in some genera—"*Stewart's Organs*," or *Internal branchiæ*. External branchiæ occur in some orders which are thus *ectobranchiata*. The orders without them are *anectobranchiata*.

The *ambulacral plates* are always perforated by *canals* (one, two, or many) ending externally in pores; the *interradia* are more or less perforated in the Clypeastroida; the *water-system* from within becomes connected with *Tentacles* or *Pedicels* which are placed outside the test, their bases covering a *pore* or a pair. The surface of all of the plates of the test is tuberculate or granular, and may have *epistroma*; the tubercles carry *spines*, some minute ones, and some granules support the *stalks* of *pedicellariæ*; *sphæridia* occur in the actinal part of the ambulacra. They are usually visible, but may be hidden.

Plates.—Tests may be *rigid* or more or less *flexible*. Plates are more or less geometrical, calcareous pieces forming the *interradia, ambulacra, dorso-central system, perignathic girdle*, and are found upon the *peristomial* and *periproctal* membranes; they are named according to those parts of the test, and may be numerous or few. Composed of lax or close branching rods of carbonate of lime and intermediate organic structure, of cleaving calcite in fossils. A plate has an *inner* or visceral surface, an *outer* with *tubercles, granules*, and *epistroma*: and edges, the more or less transverse of which are dorsal and actinal or aboral and adoral; the remaining edges are vertical or aslant. The edges of plates are in contact with those of others around, and the plane of junction, or union, is the *Suture*. The edges in contact may be fused or inseparable, or in simple contact through the intervention of a thin organic tissue; or the edge of one plate may carry knobs which fit into sockets upon the opposite edge (dowelling); or *laminæ* of one edge dovetail into grooves in opposite edges. The outer part of the suture (the *line of suture*) is often visible at the surface of the test between plates, and may be a simple line, or a *slight* or *deep groove*, with or without *pits* and *deep undermining hollows*. Plates may be united by soft structures in which there is no carbonate of lime, and then there is no suturing, but more or less flexibility of the test or part of it. The plates of the *peristomial* and *periproctal* membranes are thus separated. The sutures which are vertical and pass down in the median line of the interradia and the ambulacra are *Median*; the sutures between the ambulacra and interradia are *Ambu-*

lacro-interradial; all others are *Transverse*. *Overlap* or imbrication of the edges of plates may occur when the plates are separated by organic material, although there is no *obliquity* of the thin edges of the plates. *Overlap* usually occurs when the plates are in direct contact, and hence obliquity of the edges; the direction of the plane of suture is then not at right angles with the surface of the test, but more or less aslant. In overlap the edge of a plate overrides or overlaps the corresponding edge of the plate placed actinally or dorsally or at the side. The overlap occurs both in thin and in thick tests and has definite directions. The overlap of the *ambulacral* plates is *adoral* or *actinal*, that is the *actinal* edge of a plate overlaps the *abactinal edge* of the plate situated below or actinally to it. On the other hand, the overlap of the *interradial plates* is *aboral* or *abactinal*, and the abactinal edge of a plate overrides the actinal edge of the plate placed dorsally to it. It is understood that the observation must be made of the outside of the test. Overlap may occur at the sides of plates and in the interradia, from the median vertical line outwards.

Coronal plates are those between the peristomial margin and the apical system; *peristomial* marginal plates surround and form the *peristome*; *buccal* or *peristomial plates* are in rows or are isolated within the *peristomial* margin in the line of the ambulacra; *periproctal* plates are upon the *periproctal membrane*; *anal* plates are close to the anal orifice in the *periproctal membrane*.

Interradial plates are simple and variable in number. *Ambulacral plates* are usually in two vertical rows, but there may be more; the plates are either simple or *compound*; and in the first case they are in the great majority of instances *primaries*, that is they extend from the outer edge of an ambulacrum to the *median suture* of the area. When *compound* they are composed of two or several *components*, all of which are joined by sutures and form a geometrical plate; some components are *primaries*, that is extend from the side of the ambulacrum to the median line; others are *demi-plates* and do not reach the median line. The *direction of the lines of suture* of the components of a compound plate varies in different families.

A plate is said to be *occluded* when it reaches the median line, but does not touch the *ambulacro-interradial vertical suture*. The plate may be *isolated*, and then it is shut out from the median line as well as from the edge of the ambulacrum. Each plate, whether simple or forming part of a compound plate, or a solitary demi or occluded plate, is perforated either by two canals, and shows externally a pair of pores, or by a single canal, or by several, each having one pore externally. (See *Tentacles*.)

Tubercles are *primaries* when fully developed and larger than others, which are "*Secondaries*." They have a *base*, the "*Boss*," which carries the "*Mamelon*;" the upper part of the *Boss* may have crenulation, *or be crenulated* (more or less vertical ridges and grooves all round the upper part) or not, and then it is said to be *plain*; the mamelon may have a circular foramen leading downwards from the apex for a slight distance, and is then "*perforated*," or the perforation may be absent, and the mamelon is "*imperforate*." A plain or a sunken space may surround the base of the Boss of primary tubercles, which is called the "*Scrobicule*" or

scrobicular area: its outer limit, more or less circular, is the *scrobicular circle*, and may or may not be perfect; if not, the scrobicule of one tubercle will be found to merge into those of the tubercles placed dorsally and actinally to it, and is "*continuous*." *Secondary tubercles* may or may not have scrobicules. Very small tubercles incomplete in their division into parts are *miliaries*. *Granules* are more or less nodular projections of the test, and may be large and distant or very numerous and like shagreen, and all intermediate sizes are seen. The tubercles carry *spines*. The miliaries and granules may carry small spines or pedicellariæ.

Lovén has lately pointed out that much of the ornamentation of certain genera, such as ridges, all moniliform, pedunculate, and large granules, linear or vermiform elevations, and groovings, is due to the calcification of a membrane placed in early life upon the plates. This ornamentation is *Epistroma* (Lovén, Ech. desc. by Linnæus).

Dorso-central or Apical System.—This is abactinal or dorsal, and consists of *Basal plates*, *Radial plates* united by sutures or fused or separated by soft tissue (formerly termed Genital and Ocular), the madreporite, and of the periproctal plates in some, and sometimes of intercalated plates. In the Endocyclica the *periproctal ring*, composed of basal and sometimes of radial plates, surrounds the *membrane* and *plates* of the *periproct* and the *anal opening*, with or without anal plates. The *genital glands*, within the test, open externally by *ducts*, and one or more of them may perforate a *Basal plate*, or the perforation may be in the interradium beyond the dorso-central system. All or some of the basal plates may be thus perforated. Each *Radial plate* has a canal with a single or double orifice, and in the Palæechinoidea more than one canal may exist; the position of the opening differs, but it appears to refer to the *primitive large tentacle*, and not to an ocular organ. The *Radial plates*, five in number, may either be placed within the angles formed by the actinally projecting Basal plates, and are then *external*, or one or more may project between the Basal plates and separate them. In the Endocyclica if the Radial plates touch the margin of the periproct they "*enter the ring*." The *Basal plates* are either five or four in number, and when the latter number prevails it is due to the absence or incomplete development of the *posterior Basal plate*. The *Periproct* is within the *Dorso-central* system in the Endocyclica, and there are plates covering it more or less. The *plates* may be few and symmetrical and triangular, or numerous and more or less ovoid, circular, or irregular in outline, and placed concentrically, the largest anteriorly. A *sur-anal* plate may exist and is large, and in front of the anal orifice or in front and to the left side; rarely a somewhat *continuous pavement* of plates occurs. The plates carry spinules, tubercles, granules, pedicellariæ. The shape of the *periproct* varies: it may be circular, elliptical, or pyriform; it may have its long axis along the median line of the dorsum or obliquely to it in the Endocyclica. When the test is Exocyclic, the Basal plates may be in *contact* at their sides, forming a "*compact*" system; when some of the *Radial plates*, i. e. *the antero-lateral pair*, separate the *Basal plates*, and unite along the median line, pushing the *posterior basal plates* backwards, the system is

"*elongate;*" when the *Apical* system has the *posterior pair of Radial plates* not in contact with it, but placed *far posteriorly and separated from it* by the junction of interradial plates along the dorsum, it is said to be "*disjunct* or *disconnected.*"

The *Basal plates* project into, or are in contact with, *interradia*, and the *Radial plates* surmount *ambulacra*. In a great many genera "the *Madreporite*" is in the *right anterior basal plate*, which then is the largest; the *left anterior basal plate* is at that side of the *right anterior*, and the *postero-lateral basal plates* are immediately posterior to the anterior pair, except in *Elongate apical systems*, where, as has been noticed, the antero-lateral Radial plates intervene. The *posterior Basal plate* is in the *antero-posterior median line* of the dorsum of the test and is in contact on either side and to the front with the *postero-lateral basal plates*; or it may be absent.

The *anterior* or *odd Radial plate* is in the median line anteriorly, and is in the angle made by the antero-lateral basal plates; the *postero-lateral Radial plates* are on either side of the *posterior Basal plate*. When there is no posterior Basal plate, the *posterior pair of Radial plates* may come in contact and close the system posteriorly, or they may be separated by the *Madreporite* extending backwards. The *anterior Radial plate is No. III.*, the *left anterior Radial plate* is *No. IV.*, the *left posterior is No. V.*, the *right posterior Radial plate* is *No. I.*, and the *right anterior plate, usually with the madreporite, is No. II.* The ambulacra corresponding to the plates are similarly numbered. The *right anterior basal plate is No.* 2, the opposite or *left anterior Basal plate is No.* 3, the *left posterior plate is No.* 4, the *posterior Basal is No.* 5, and the *right posterior Basal plate is No.* 1. The interradia in relation with the Basal plates are similarly numbered. (See Lovén, Études.)

The Madreporite.—A cribriform structure consisting of *canals*, tubular in shape, variable in number, with reticulate carbonate of lime between them and forming their walls, opening at the surface of the test, the orifice or orifices being minute and rather close, leading into the test to a canal which is in communication with the water-system and a renal organ. It has no especial plate and the tubules of the body may be *restricted* to the area of the right anterior Basal plate, or may extend and perforate other Basal plates and even some interradial plates. The Madreporite may exist so as to *separate* some of the basal plates in the Exocyclica, to form much of the centre of the system, and it may pass backwards separating the posterior Basal plates and even the posterior Radial plates, and may abut against the posterior interradium. In some Clypeastroida there may be but one pore in the *Madreporite*, or two or three situated along a narrow groove; in the majority the body may be *central*.

When a *Madreporite* in the Exocyclica is bounded posteriorly by the posterior pair of Basal plates, Nos. 4 and 1, the apical system is *Ethmophract*; but when the posterior Basal plates and the Postero-lateral Radial plates are pushed on one side by the Madreporite, the arrangement is *Ethmolysian*. (See Lovén, Études.)

In the Exocyclica the periproct is in the median line of the posterior ambulacrum, beyond the apical system; it may be circular, elliptical,

oval, large or small, and even deformed and oblique; it may be supra-marginal, marginal, or infra-marginal; it has plates surrounding the anus, sometimes numerous, rarely few and triangular.

Ambulacrum, one of the five *ambulacra*. (See *Test*, *Dorso-central System*, *Plates*.)—Consists of an *interporiferous area*, which is placed between the two *poriferous zones*. The ambulacra may be straight, curved, wavy, subsigmoid, flaring, broad, narrow, flush or sunken, according to the usual meaning of the words; their path is dorsal, ambital, actinal, peristomial, and buccal—these being the regions of the test passed over. They are *similar*, or, when the anterior one differs from the others in its pores, *dissimilar*; they are either *Close* at the Apex, or *Disconnected* when the posterior Radial plates are disjunct. They are named according to their position, and are:—1, *Anterior or odd*; 2, *Antero-lateral, right and left*; 3, *Postero-lateral*, also *right and left*. Each ambulacrum being associated with a *Radial plate*, assumes the number of that plate in Lovén's terminology. Ambulacra may have their dorsal portions petaloid and the rest simple, except often near the peristome. In the Exocyclica the anterior ambulacrum and the antero-lateral pair are sufficiently connected to form a *Trivium*, in contradistinction to the postero-lateral pair, which then form a *Bivium*. The termination of the ambulacrum at the *Peristome* is the *peristomial margin* of it. The *petaloid* parts are either flush with the test, or project and are tumid, but most commonly they are slightly or considerably sunken, and in the last instance they frequently are *Marsupia*, or receptacles for the immature young; they may be in deep and narrow or broad grooves.

The areas have primary and secondary tubercles in vertical rows, or the last kind may be irregularly disposed or in scrobicular circles around the *primaries* (see Plates). *Granules* occur and *Epistroma*.

The *poriferous zones* are on either side of an interporiferous area, except in some Palæozoic genera, where all the ambulacrum is poriferous. The arrangement of the pairs of pores may be in *simple series*, that is to say one pair is placed over the other from peristome to apex; or they may be placed so that there are two vertical series, one nearer the ambulacro-interradial suture than the other, they are then termed "*biserial*" (bigeminal of authors); or there may be three vertical rows of pairs, the arrangement being "*triserial*" (trigeminal); or there may be a crowded and apparently disorderly arrangement of the pairs near the peristome, and it is "*Polyserial*."

Simple series of pairs of pores are either absolutely straight or in *arcs* of three or more pairs. The *innermost*, and therefore the lowest or *adoral* of the pairs of an *arc* of three pairs, is usually connected with the *adoral plate* of a *compound plate*, and when there are *biserial* pairs the distribution of the three pairs in an arc is closer and wider apart laterally (see *Echinothrix*, fig. 7, pl. v. Linn. Soc. Journ. xix.), or as in *Micropyga* (see same plate, fig. 11). The *adoral pair* of the *triplet* is then not always the most internal of the three. (It is clear that there are three pairs of pores to each compound plate of the biserial *Micropyga*, and therefore the word bigeminal, which used to be the term, is incorrect.) Pairs are said to be in

oblique series, or to be *oblique*, when there is an outward slant of three or more consecutive pairs from above downwards; but it will be found, as a rule, that the *highest*, and therefore innermost, of the three pairs is the *adoral* pair of a *compound plate*, as in *Pedina*. In every pair the pore which is nearest the interporiferous area is the adoral of the two, or was so at an early age, and is or was in contact with the transverse suture of the plate; but during the growth of plates the pair may become removed from the neighbourhood of the suture, and the adoral character lost. *Uniporous zones* occur in parts of ambulacra and sometimes throughout. *Polyporous ambulacra*, as in Clypeastridæ, are those in which besides the usual pairs numerous *single pores* exist throughout or in part of the ambulacrum. Pores are *similar* when both of a pair are the same in shape; *dissimilar* when the outer pores of a series of pairs differ in shape and size from the inner series. Pores become *obsolete* or *rudimentary* or very small in the zones between Internal Fascioles and the Apical system. Pairs of pores may either be *flush* with the test or open out in slightly raised elliptical rims, called *peripodia*; there is usually a *septum* between the pores of a pair, and there may be a *costa* between each pair of pores.

Ambulacra are *simple* when the pairs of similar pores keep to slightly curved lines of vertical direction, as in *Cidaris*, *Diadema*, and *Echinocorys*; and they are then often termed *apetaloid* in contradistinction to the *petaloid* condition. *Petaloid ambulacra* are those which enlarge between the apex and the ambitus, and contract again more or less perfectly before reaching that region; they have large pairs of pores, and the outer pores of pairs are usually broader than the inner, and this dissimilarity increases with the boldness of the curvature of the zones. *Subpetaloid* is a term given to ambulacra similar to those just noticed, but the pairs of pores do not tend to close distally. The pairs of pores at the peristome or close to it may be simply *crowded*; or they may be in a pattern forming a kind of petal, some of the pairs being wider apart than others, and some put out of place and "*doubled*," this arrangement is a "*Phyllode*." When accompanied by ornamentation of the *tumid interradial peristomial margins* (bourrelet), the whole forms a "*Floscelle*."

The "*Tentacles* or *Pedicels*" of the ambulacra are placed over the peripodia, and single, and may be *prehensile* and end in a *disk*, or be *branchial* or *penicillate**; they may be of the same kind or they may differ in the same ambulacrum, especially if there are fascioles crossing the areas, and then the tentacles of the peristomial region differ from those of the dorsal. The tentacles of the ambulacra are *homoiopodous* when they are similar, and *heteropodous* when they differ in shape, construction, and function; *subheteropodous* when the abactinal tentacles are partly branchial and partly and feebly prehensile, the actinal being with disks; *subhomoiopodous* when the actinal tentacles, although modified, still have suckers. *Branchial incisions*, *grooves*, or *cuts* are notches in the *peristomial margin* for external branchiæ, are on either side of *each ambulacrum* in some orders of the Endocyclica, and there may be a "*Tag*"

* O. F. Müller, 1789, 'Zool. Danica,' vol. iii. p. 18.

or piece of plain test passing for some distance dorsally from the grooves, and they are in relation to small tufts of *external branchiæ.*

Spheridia are either placed visibly upon short stalks in the ambulacra, usually near the peristome, or they may be partly or entirely covered by test; they vary in number and exact position, and are opalescent spheroidal bodies. (See Lovén, Études.)

Interradium.—One of the five areas which are placed between the ambulacra, and reach from the basal plates of the apical system to the peristome (*coronal*), and in some instances to the mouth (*peristomial*).

The plates are more or less geometrical and in vertical rows, and are united by transverse and oblique sutures with those above and below, and a median suture (or in some Palæozoic forms sutures) unites them also at the side. Variable in shape and in number; when in more than two vertical rows those nearest the ambulacro-interradial sutures are "*adambulacral.*" In the Euechinoidea the interradia correspond with basal plates, and are numbered as they are, and receive the same orientation. In the Exocyclica the *posterior interradium, No.* 5 (Lovén), has the periproct occupying some space at the median line or suture; and in Spatangoida the *posterior interradium* is long, and often forms actinally a *sternum*, preceded at and towards the peristome by a *labrum*, forming the posterior edge of the peristomial margin, followed or not by an *episternum.* When there is a large plate on either side of the median line of the sternum, the test is *amphisternous*; and when there is more or less of a zigzag and the plates are not arranged symmetrically on either side of a median line, the test is *meridosternous* (Lovén, 'Pourtalesia'). The interradia may enter the peristomial margin, each with two plates, or with only one, as in *Cassidulus* and in Spatangoids and Clypeastridæ. The interradia are usually *continuous* from apex to peristome, and in Cidaridæ and in some Palæechinoidea they are continued beyond the peristome associated with ambulacral plates to near the stoma. But *discontinuity* may happen by the enlargement of ambulacral plates blocking out the union of the *first and second peristomial interradial plates*, leaving a circle of ambulacral plates, as in *Mellita* (Lovén, 'Études'). There is a want of symmetry and similarity between the arrangements of the plates in the *postero-lateral pair of interradia* (Nos. 1 & 4), and this is produced by the fusion of certain plates in the actinal region of the *right postero-lateral interradium No.* 1 (Lovén). The anterior part of the *interradium* is *zone b*, and the *posterior* zone next to the postero-lateral ambulacrum is *zone a*. (For descriptions of this want of symmetry, ancient and modern, see Lovén, 'Études.')

Union of the second and third (2 & 3) plates of zone *a*, no such union happening in the corresponding zone of interradium *4*, is *normal heteronomy* of interradium *1*; union of the second plates of zone *a* and zone *b* in interradium *1* is *ancient heteronomy*. Irregular heteronomy when the plates 2 & 3 of zone *b* unite with plate 2 of zone *a* in interradium *1*, the plates 2 of both zones of interradium *4* also uniting (*Palæostoma*).

The *Peristome*, more or less central and actinal in the Endocyclica, is sunken or flush, decagonal, pentagonal, with or without branchial incisions or cuts; the margin is composed of ambulacral and interradial plates,

and these may or may not be carried on as far as the true mouth; or isolated buccal plates occur.

In the Exocyclica the peristome varies in shape and position, usually actinal, and usually excentric in front; it may be quite anterior, as in *Pourtalesia.* It may be elliptical, decagonal, circular, oblique, pentagonal, or semilunar with a posterior labrum. It has a plating upon its membrane.

Perignathic Girdle (see *Test*) does not occur in Spatangoida: is *continuous* when there are *processes* ambulacral in development, usually arched over, and connected at their sides by *ridges* consisting of turned up and fused interradial plates (Duncan, Journ. Linn. Soc. xix. p. 179); is *discontinuous*, as in *Cidaris* and Clypeastroids, when there are either simple ridges or simple processes without their union.

Jaws.—In the Endocyclica the *pyramids* are five in number, and each has a *grooved* or a *keeled* tooth, pointed actinally. The pyramids are in muscular contact at their sides; and at their upper junction is a "*brace*" radiating outwards from the central axis of the jaws, which is occupied by the œsophagus; a long, bifid process, the "*rotula*," or *compass*, is above each *brace*. The *projecting* part of the pyramid bulges outwards at the median line, and in some genera it is solid almost to the upper part, a very small notch or foramen existing; but in others there is a large *foramen*, which is arched over by apophyses of the sides of the top of the pyramid; the tooth is just within this median projecting part. The jaws of the Clypeastroids are differently formed, and in the majority of genera overlie and are rarely within the single or double *discontinuous perignathic processes and ridges*, as the case may be. They have each pyramid more or less *concave* and *re-entering* at its median line; the projection is at the junction of two pyramids over the ambulacrum within the test, the reverse of what occurs in Cidaroida for example. In Clypeastroida the jaws are low, often *unsymmetrical*, and the teeth are *aslant*, or even nearly *horizontal.* Moreover, the *foramen* is absent, and the *compasses* also, the *braces* being rudimentary and not found at the upper junction of two pyramids.

Fascioles are narrow bands of close granular ornamentation, which support rudimentary spinules and pedicellariæ. The "*peripetalous*" fasciole environs the petaliform parts of the ambulacra, often keeping close to them; the "*lateral*," or more properly termed "*marginal*," encircles the test about or above the ambitus; and the peripetalous fascioles may have a *posterior lateral branch* passing beneath the anus, sometimes called "*infra-anal.*" The "*subanal*" fasciole encloses a space or *plastron* perforated by pairs of pores, placed beneath the anus, and it may send *anal branches* upwards on either side of the anus, and they may enclose it, forming an *anal* fasciole. The "*internal fasciole*" crosses the ambulacra at a greater or less distance from the apical system. The *internal* fasciole and the *subanal* fasciole are accompanied by modifications in the structure of the plates and tentacles enclosed within their areas, and are of much importance in classification. Spatangoids have *fascioles*, and those genera of the group without them are

Adetes, the genera with *subanal* fascioles are *Prymnodesmia*, and those without them and with other fascioles are *Prymnadetes* (Lovén).

Spines vary greatly in dimensions, and in the shape and nature of the transverse section; may be hollow or more or less solid and reticulate centrally; externally with close or distant wedges, or a merely solid circumference. They consist of a shaft variously ornamented, of a base which is hollowed for the condyle or cup part of the joint for the reception of the ball or mamelon of the articulating tubercle. The base may be plain, or it may be crenulate, and will then correspond with a crenulation on the ridge surrounding the base of the mamelon. The crenulation varies in amount, and it may be present in some and absent in other tubercles and spines upon the same test. The opposed crenulated surfaces give attachment to the dense capsule of the joint, and there are no muscular fibres in connection with them. Above the base of the spine, is usually, but not invariably, a more or less symmetrical collar, which projects beyond the shaft, and is sloped upwards to the shaft and ornamented with the striations or grooves and ridges of the spine. The muscular fibres which move the spine are inserted just below the collar, or upon the whole of the underpart of it, and they arise from the edge of the scrobicule close to the scrobicular circle of granules or tubercles, and may form a sheath. Some spines are fixed, and arise at once from the test, as in *Podocidaris*. (For general and especial structure see A. Agassiz, 'Revision,' and Reports on the 'Challenger' and 'Blake' Echini; Mackintosh, Trans. Roy. Irish Acad. 1878.)

Pedicellariæ have a short or long calcareous stem articulated upon granules, and a short or very long flexible and soft part upon which is the head, formed by either two or by three valves. The stem may be glandular or not, and glands exist in many instances within the head, also muscular fibres and nerves. Pedicellariæ have been classified under three terms, and O. F. Müller, 1788, Zool. Dan. vol. i. p. 16, called them *P. globifera*, *P. triphylla*, and *P. tridens*. The first have a spherical head and no neck, the second have a bilobate short head and a produced neck, and the third have a bilobate long head often with slender valves and a neck. These terms are quite as useful as the more modern equivalents—*P. gemmiforma*, *P. ophiocephala*, and *P. tridactyla*. The "*Globifera*" of Hamann are large tripartite glands without an internal calcareous support.

The figures of Pedicellariæ in the Zool. Danica, vol. i. pl. xvi., 'Revision of the Echini,' and in the Reports upon the 'Challenger' and 'Blake' Echini, by A. Agassiz, should be studied; also Valentin, 1841, Anat. Gen. *Echinus*, in Agassiz, Monogr. d'Éch. viv. et foss.; Sladen, 1880, Ann. & Mag. Nat. Hist. ser. 5, vi. p. 102; Hamann, 1886, Sonder-Abdruck aus den Sitzungsb. d. Jenaisch. Gesellsch. f. Med. u. Naturw. See also remarks by Döderlein, 1885, Archiv f. Naturg. (Wiegm.), i. p. 82.

SUPPLEMENTARY NOTE.

The following Note was written during the printing of this "Revision" (Oct. 16th, 1889).

An important work came to hand after the reading of this "Revision," and the following are necessary remarks:—

Explorat. Sci. de la Tunisie, Ech. Foss., 1889, MM. Thomas et V. Gauthier.

Genus *Opisopneustes*, Gauthier, 1889, p. 2. This, according to the system adopted in this "Revision," is a subgenus of *Hemipneustes*.

There is not sufficient structural difference between *Holaster* and a genus *Pseudholaster*, Pomel, 1883, adopted by M. Gauthier, and the first-named genus absorbs the other.

Plesiaster, Pomel, adopted by M. Gauthier (p. 26), is said to be a *Micraster* with a peripetalous fasciole; but, considering the shape and the distribution of the species of *Metalia* from Sind, and the existence of the genus *Meoma*, it is impossible to recognize the proposed genus without further knowledge about the anatomy of the test.

Had M. Gauthier had the advantage of seeing the great collection of species of *Plesiolampas*, Duncan and Sladen, from Sind, he would have placed his genus *Hypopygurus* in it. There is no distinction.

Pygopistes, Pomel, 1883, admitted by M. Gauthier, comes within *Catopygus* (see *ante*, p. 185). *Parapygus*, Pomel, is inseparable from *Echinanthus*.

Genus *Adelopneustes*, Gauthier, 1889, *op. cit.* p. 52, is a good and most interesting genus belonging to the Echinoconinæ. It has the characters of *Echinoconus*, but the ambulacral plates are few, high, and single, and each has a pair of very small pores. Cretaceous; Tunis.

Rachiosoma, Pomel, 1883, is a *Cyphosoma*.

Thegaster, Pomel, 1888, when compared with fossil and recent *Fibulariæ* (see especially the tumid forms described by A. Agassiz), clearly is a true Fibularine, and synonymous with *Fibularia*.

Pliolampas, Gauthier?, *op. cit.* p. 97, appears to be a *Palæolampas*, Bell, with a produced rostrum and periproct.

Orthechinus, Gauthier, p. 105, admirably described, covers the same ground as *Thylechinus*, Pomel (amended), see p. 89 of this "Revision." M. Gauthier's generic name is the best.

Subgenus *Radiocyphus*, Cotteau, 1888 (genus), Compt. Rend. de l'Acad. des Sci. vol. 107, is a subgenus of *Acanthechinus* (see *ante*, p. 289) with perforate and crenulate tubercles.

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ADDENDA ET CORRIGENDA.

Phormosoma, p. 42. Prof. Jeffrey Bell has shown (Ann. & Mag. Nat. Hist. 1889, ser. 6, vol. iv. p. 436), during the printing of this Revision, that in *Phormosoma placenta*, Wyv. Thoms., the internal branchiæ, or "Stewart's organs," may be present in a rudimentary or vestigial condition. He observes that the organs are not to be traced in *P. bursarium* and *P. tenue*; but he does not lay much stress upon this, as the specimens, unlike those of *Phormosoma placenta*, had been for many years in spirit. The longitudinal internal muscles, so well described by Drs. Sarasin in *Asthenosoma*, are absent in *Phormosoma*. It is difficult to make out whether the indications of the presence of the organs, in the drawing given by A. Agassiz of *P. tenue*, 'Challenger' Report, pl. xiv. fig. 2, are really not intestinal. This appears to be the case in pl. xii. fig. 2.

It is necessary, thanks to Prof. Bell's work, to make the following corrections:—

Phormosoma, p. 42, should be in a new subfamily of Echinothuridæ.

Therefore:—

P. 40, 5 lines from bottom, *after* "a series of longitudinal muscles" *add* "may exist or not;" and 6 lines from bottom, *after* "internal very large" *add* "or ill developed."

P. 43, 14 lines from bottom, *add* "Internal longitudinal muscles absent; *internal branchiæ small or rudimentary.*"

P. 44, 20 lines from bottom, add "*Internal branchiæ large; internal longitudinal muscles developed.*"

P. 45, 13 lines from top, *for* "Cyphosomidæ" *read* "Cyphosomatidæ."

P. 207, 20 lines from top, expunge "Syn. *Guettaria*, Gauthier, 1887. *Entomaster*, Gauthier, 1887."

Passim, for "Péron" *read* "Peron."

M. V. Gauthier has obligingly sent me his generic descriptions of *Guettaria* and *Entomaster*, which were not available before the last sheet but one of this work was in the press.

Genus GUETTARIA, *Gauthier*, 1887, *Assoc. Franç. pour l'Avanc. d. Sci.* (Toulouse), p. 528.

This genus is allied to *Cardiaster*, and has a deep narrow anterior groove actinally, with a sunken and almost circular peristome in it; the tubercles are larger than in *Micraster*, and there is a posterior notch resembling that of *Hemipneustes*. There are two large pores besides the small tentacular pore in each antero-lateral radial plate.

Cretaceous: Africa, Tunis, and Madagascar.

The genus *Entomaster*, Gauthier, 1887, *op. cit.* pl. xvi., appears to be of subgeneric value, like *Lampadaster*, Cott. I place it provisionally as a subgenus of *Holaster*.

Cretaceous: Africa, Tunis.

Intensive Segregation, or Divergence through Independent Transformation. By Rev. John Thomas Gulick. (Communicated by W. Percy Sladen, F.L.S.)

[Read 19th December, 1889.]

In a previous paper on "Divergent Evolution through Cumulative Segregation" * I have enumerated eighteen classes of natural causes which produce either Separate or Segregate Generation †, and which, in their combined action, tend to produce cumulative Segregation and divergent evolution in every part of the organic world. I have there shown, with sufficient fulness, that cumulative Segregation always produces cumulative divergence or polytypic evolution; but I have not fully shown how Separation from the first involves more or less Segregation, or how Segregation, that at first divides the species into sections with reference to some one endowment, is always tending toward intensified Segregation in which the sections present differences in regard to an increasing number of endowments.

After expounding the principles on which these laws of divergence rest, I will give a few examples of divergence, calling attention to the complete correspondence between the facts of nature and the principles expounded in this and the previous paper.

Separation always involves more or less Segregation, for no two portions of a species possess exactly the same average character. When a homogeneous species is divided into two large sections,

* Journ. Linn. Soc., Zool. vol. xx. pp. 189-274.

† Separate Generation, or Separation, is the indiscriminate division of a species into sections that do not intergenerate. Segregate Generation, or Segregation, is the Independent Generation of different sections of a species when the sections are composed of somewhat divergent classes of variations. Segregation differs from Selection in that the latter denotes the exclusion of certain kinds from opportunity to propagate, while the former denotes the division of those that propagate into classes that are prevented from intergenerating. I use intergenerate rather than interbreed that I may have a term equally applicable to plants and to animals. Independent Generation, or the prevention of intergeneration, whether it be through Separation or Segregation, I sometimes call Segeneration. Darwin used Isolation as equivalent to geographical separation, while later writers have sometimes used it as equivalent to Independent Generation. Following Darwin, I use it for distribution in different areas, especially when barriers intervene.

it may be difficult to prove by measurement that there is any difference in their average character; but on general principles we may assume that, at least in some points, there is a slight difference. It is evident that when the separated sections are small there is more likely to be *diversity* in the average character of the sections, and that, roughly stated, the probability of divergence from this cause will be in direct proportion to the variableness of the species, and in inverse proportion to the size of the different sections. When a few stragglers form a small colony in an isolated position there is the strongest reason to expect that they will not be able to propagate the characters of the species in exactly the same proportions in which they are produced by the main body of the species, or by any other small colony that is propagating independently; and when the original stock has been rendered highly variable by the crossing of somewhat divergent varieties, the degree of difference that will probably be presented by any two independent colonies will be correspondingly increased. We must bear in mind that, while specimens possessing an average character in any one respect are always abundant, those perfectly representing the average in every respect are rarely, if ever, found. Now, is it to be supposed that any one, or any small number of these imperfect representatives of a species will, if separated from the rest, transmit all the characteristics of that species in the exact proportions presented by the average character of the original stock?

Mr. Francis Galton has conclusively shown* that in the children of parents whose heights deviate from the average of the race to which they belong there will be a similar deviation amounting on the average to a certain fixed proportion of that presented by what he calls the mid parentage. The mid-filial deviation in the groups investigated by him was about two thirds of the mid-parental deviation. There is therefore a regression in the average character of the offspring toward the typical character of the group. It must be observed, however, that this law can hold in full force only where there is free crossing, otherwise no divergent race could ever be formed by any amount of selection and independent breeding.

* See "Types and their Inheritance," an address before the Section of Anthropology of the British Association in 1885; also 'Natural Inheritance,' p. 97.

Eight Principles of Monotypic Evolution.

Let us now consider how this initial Segregation, which is always present where migration or geological subsidence produces indiscriminate Separation, is enhanced and intensified by the cooperation of other principles, and how forms, segregated through possessing different characters in some one respect, come to diverge in other respects. For example, when differences of colour become the occasion for sexual and social Segregation, how does this open the way for divergent transformation in habits of feeding and in a thousand other respects? The principles co-operating with Independent Generation in producing this enhanced divergence are all causes of simple transformation, or monotypic evolution when there is free intergeneration. Divergent breeds of domestic animals have always been produced when the different sections of a species in the care of different races of men have been prevented from interbreeding, thus securing their Independent Transformation during the process of domestication. So in nature, when any form of Independent Generation has been established, any cause of transformation that may afterwards arise will always produce more or less divergent evolution, and never that which is in every respect parallel. But we must defer the discussion of this subject till we have enumerated the more manifest of the principles of monotypic evolution:—

1. *Assimilational Transformation*, or modification due to deficiency with economy, or redundance with profusion, of growth, resulting from different degrees of assimilative power. "Economy of growth" is a term already in use, but a term is needed that shall include both this and its opposite.

2. *Stimulational Transformation*, or modification produced by changed motions in the fluids of an organism responsive to changed molecular influences in the environment. Under this principle we may place the direct influences of light, heat, electricity, the dampness of the air or the saltness of the water in which the organism is bathed, the quality of the food, and all stimulation from physical and chemical causes, exclusive of those resulting in muscular activity or the movement of organs.

3. *Suetudinal Transformation*, or modification due to the effects of use, disuse, and habitual effort in producing motions, and in resisting the strain of gravity and other forces tending to produce motion. Suetude is not found in the dictionary, but I venture

to use it as including both assuetude, which is being accustomed to, being practised in, habitual use,—and desuetude, which is disuse, discontinuance of practice. This principle has been recognized by most biologists, though it has recently been called in question by Weismann.

4. *Emotional Transformation.*—Dr. C. V. Riley, of the National Museum, Washington, has called attention to the influence of parental emotions, especially maternal emotions during the term of pregnancy, as a factor in evolution (Address "On the Causes of Variation," before the Section of Biology, American Association, August 1888; also in 'Popular Science Monthly,' vol. xxxiv. pp. 811–816).

5. The cumulative development of adaptations through "the survival of the fittest" when the fittest are other than average forms. This is the principle of *Unbalanced Selection* or of *Selectional Transformation.*

6. Transformation produced by the indiscriminate destruction of a portion of a species, with the accompanying probability that the remaining portion will not possess all the characters possessed by the species previous to the elimination. This principle I call *Unbalanced Elimination,* or *Eliminational Transformation.*

7. Transformation produced by different degrees of amalgamation of the varieties and races which have resulted from previous Segregations. In most species there is a constant process of amalgamation by which thousands of minor varieties are absorbed; but when the process proceeds beyond ordinary limits, and the barriers that have divided well-marked races give way, transformation must follow. This principle I call *Diversity of Amalgamation,* or *Amalgamational Transformation.*

8. The cumulative development of the more fertile of the forms that are equally adapted. In other words, transformation produced by diversity in the relative fertility of varieties that are equally adapted to the environment and the constitution of the species, or by change in the degrees of fertility possessed by the same variety at different times and in different places. This principle I call *Unbalanced Fecundity,* or *Fecundal Transformation.*

Of these principles, all, except the 6th, 7th, and 8th, have been more or less discussed by writers on biology, though some of the forms of Selection depending on the relations in which the members of a species stand to each other have never been

pointed out, and many writers have failed to observe that natural selection often produces fixity of type instead of transformation, and that divergence in the kinds of natural selection depends on Segregation, and not necessarily on exposure to different environments.

Assimilational, Stimulational, Suetudinal, and Emotional Transformation belong to a class of principles that have sometimes been grouped under the term Variation, while Selectional, Eliminational, Amalgamational, and Fecundal Transformation may be classed as *principles of Unbalanced Propagation*. It should, however, be carefully noted that Variation usually indicates deviation from the average, an entirely different factor from those which relate to the change of the average itself. It may therefore be well to group these first four principles as *principles of Involution*. The principles of Unbalanced Propagation are abundantly established as genuine methods of change in the average inheritable characters of species, not only by experience derived from the domestication of plants and animals, but by observation of similar effects produced by natural processes. On the other hand, the principles of Involution, though very marked in their influence on individual character, cannot be easily tested as to their effects on the inheritable characters of species. Weismann maintains that acquired characters cannot be inherited. If this is so, there can be no involution of specific characters, and the only factors in monotypic evolution are the causes whose laws of action are expressed in the principles of Unbalanced Propagation.

I have not mentioned "Acceleration and Retardation" as principles of transformation, for they seem to be but phases of the law of Suetude; for, as explained by Cope, the former is the effect of Use or Effort in the parents, producing in the offspring accelerated inheritance, while the latter is due to Disuse or Cessation from Effort, producing in the offspring retarded inheritance *. So also Hyatt's "law of Concentration" (or "Acceleration," as he often calls it) seems to be a general law of inheritance relating to the transmission of characters originating under any and every principle, the effects, whether progressive or retrogressive, being inherited at earlier and earlier ages in each successive generation †. It is also doubtful whether Correlated

* 'Origin of the Fittest,' pp. 203-7, 228.

† 'Proceedings of the American Association,' vol. xxxii. pp. 352-361.

Transformation should be considered a separate principle, for it seems to be simply the inheritance by offspring of characters that have for many generations been united in the endowments of at least a portion of their ancestry, and the correlation of these endowments must have been produced through the action of other principles.

The prevalence of males in times of pressure, with the prevalence of females in times of plenty, is regarded by Dr. W. K. Brooks, of Johns Hopkins University, as a characteristic established by natural selection, by which the organism acquires variability or fixity of type according as either character is most needed; for according to his observations the males represent the former, and the females the latter element. There can be no doubt that in many species the males are more variable than the females, and that in some of the same species the proportion of males increases with the degree of adversity; but this does not seem to be sufficient ground for maintaining that the increase in the proportion of males will increase the variability of the offspring. Increase in the number or amount of the variable element does not necessarily involve increase in the variability of either element, or in the offspring of both. I find need of additional factors in order to bring these facts into any relation to the increase of variability. Granting that the sperm-cell is the source of variation and the germ-cell the source of fixity, and that increased tendency to variation in the offspring will be secured by an increased range of variation in the sperm-cells, it does not follow that increase in the relative number of males will increase the range of variation in the sperm-cells, and therefore in the offspring. But if conflict with the environment and the winnowing process of natural selection falls most heavily upon the males, there must be some advantage in having their relative numbers increased in times of adversity; and if the exposure of parents to hardships increases the variability of either male or female offspring, and especially if it increases the variability of both, plasticity will be increased.

Prof. Cope's "Doctrine of the Unspecialized" ('Origin of the Fittest,' pp. 232–5) rests on the fact that the most highly specialized types, as well as individuals, are most likely to be exterminated by extraordinary changes in the environment; and Mr. Hyatt's "Geratology" ('Proceedings of the American Association,' vol. xxxii. pp. 349, 360) teaches that types that are being slowly exterminated usually assume forms resembling those produced by

old age and disease in the individual. These and other parallel laws in the growth and decay of types and individuals are of great interest, as they afford organic conditions under which the principles of transformation must act.

After considering certain general propositions that apply equally to all of the eight principles above enumerated, I shall consider more particularly what the effect of some of these principles is when cooperating with Independent Generation. The only principles I shall treat in this special way are the four principles of Unbalanced Propagation.

The Transformation of freely Intergenerating Organisms never Divergent.

I mention these eight principles of transformation, not with the purpose of entering upon a full discussion of the same, but simply to point out the relation in which they all stand to divergent, or polytypic, evolution. It is evident that whether acting separately or together, they can never be the cause of divergent evolution in organisms that are freely intergenerating; for in such a group of organisms whatever modifies one part of the group in characters that are inheritable will ere many generations modify the whole. If the group is exposed to a variety of inharmonious conditions, which with Independent Generation would produce divergent character, with free Intergeneration the only result will be variation. Without Segregation there can be no permanent divergence; and with Segregation there must be divergence; and with cumulative Segregation there must be cumulative divergence. This principle, which I call *Divergence through Segregation*, was the subject of my previous paper.

Independent Transformation never Parallel, but always Divergent.

If any species is divided into two or more sections that do not intergenerate and that are severally subject to highly complex transforming influences, it can only be by a series of coincidences which the reason refuses to receive as in the slightest degree probable that any two sections will be modified in exactly the same way. This high degree of probability, amounting to a certainty, that when causes of transformation cooperate with causes producing Separation or Segregation, the result in suc-

cessive generations will be increasing degrees of Segregation and of divergence, is what I call the law of *Intensive Segregation*. The different forms of this principle, resting on the certainty that the cooperation of any one of the principles of transformation with any one of the principles of independent generation will produce increasing Segregation with increasing divergence; are the following :—

1. *Assimilational Intension*, or Segregation and Divergence through Independent Assimilation.

2. *Stimulational Intension*, or Segregation and Divergence through Independent Stimulation.

3. *Suetudinal Intension*, or Segregation and Divergence through Independent Suetude.

4. *Emotional Intension*, or Segregation and Divergence through Independent Emotional Transformation.

5. *Selectional Intension*, or Segregation and Divergence through Independent Selection.

6. *Eliminational Intension*, or Segregation and Divergence through Independent and indiscriminate Elimination.

7. *Amalgamational Intension*, or Segregation and Divergence through Independent Amalgamation.

8. *Fecundal Intension*, or Segregation and Divergence through Independent Fecundal Transformation.

In groups that do not intergenerate, divergent forces reveal themselves whenever transformation is introduced. If it were possible to believe that in any case the effects of Independent Selection or of Independent Suetude had been completely parallel, it would still be impossible to believe that both of these, together with the remaining six principles of transformation, would ever so combine as to produce completely parallel effects. It is a familiar fact that no two persons are exactly alike; and it is probably true that no two groups of any organism are exactly alike. Though we cannot fully explain the fact *we accept as a certainty the non-equivalence of biological quantities*; and consequently we assume with confidence that there cannot be completely parallel transformation in isolated sections of a species, even if all are surrounded by the same environment. This principle is not inconsistent with the production of what Prof. Hyatt calls "representative or parallel characteristics" in two or more divergent series of forms. What he points out is that, under the influence of heredity, similar organisms exposed to

similar environments undergo similar transformation ('Anniversary Memoirs of the Boston Society of Natural History,' 1880; "The Genesis of the Tertiary Species of *Planorbis* at Steinheim," pp. 24–29).

In the description of these principles I have used the adjective "Independent" to signify that the principle is operating in sections of the species that are prevented from intergenerating. If Isolated Selection were used instead of Independent Selection, it would be constantly liable to be understood as meaning Selection acting upon sections produced simply by geographical separation; for Darwin never used Isolation to designate the prevention of free crossing in other ways. In the term "Independent Variation" Mr. Romanes has already used the adjective "*Independent*" as meaning "*when accompanied with the prevention of intercrossing*;" and as it is less likely to be misunderstood, I prefer it. Part of what Romanes indicates by "Independent Variation" is, I think, in my scheme distributed between the four principles of Assimilational, Eliminational, Amalgamational, and Fecundal Transformation when acting on independent groups. As these principles are quite distinct, the separate names will be a convenience. If there are other forms of transformation, the causes of which cannot be given, I would prefer to class them as due to unknown causes rather than attribute them to Variation, which, as there used, is only a name for unexplained transformation. I would not turn Variation from its usual meaning, which is deviation from the average character of an intergenerating group.

THE PERVASIVE INFLUENCE OF THE CAUSES OF TRANSFORMATION, AND THE LAW OF INTENSION.

In my paper on "Divergent Evolution through Cumulative Segregation," p. 215, I made the statement that, "When Separate Generation is long continued, we have reason to believe, it always passes into Segregate Generation with divergent evolution." The same had been expressed in a previous paper by the statement that "Variation is so strong, that all that is necessary to secure a divergence of types is to prevent their intermingling"*. The certainty that Independent Generation with transformation will never produce parallel, but always more or

* "Diversity of Evolution under one Set of External Conditions," Journ. Linn. Soc., Zool. vol. xi. p. 499.

less divergent evolution is *the law of Intensive Segregation* already referred to; but in addition to this certainty there is a very strong probability that where Independent Generation is long continued, transformation of some kind will supervene. If there are any species in which the power of cumulative variation has been entirely lost, this latter law cannot hold in their case; but it is doubtful whether among species that reproduce sexually there are many such. The variability of some species is so small, and the conditions of the environment are so constant, that comparatively long periods of Independent Generation pass before perceptible transformation arises. This seems to be the case with the 13- and 17-year races of *Cicada septemdecim*, to which I shall refer when giving examples from nature. From the high probability that long-continued Independent Generation will be followed by Independent Transformation, and the certainty that Independent Transformation will be divergent, there follows the corollary that long-continued Independent Generation will probably be attended by divergence. In other words, Independent Generation long continued is almost always attended by Independent Transformation; and Independent Transformation inevitably produces Divergence. This double principle I call *the law of Intension.* This law rests on the ubiquity of transforming influence, and on the impossibility that in a species possessing any plasticity the inherited effects in any section independently generating should be exactly the same as in any other section.

We cannot doubt that, when a diversity of powers and susceptibilities in the different sections is acted upon by a great variety of influences, the responses of the different sections will be unlike; and the result will be increasing segregation and increasing divergence. Now it is impossible to doubt that in species propagating sexually, and possessing some degree of plasticity, these are exactly the conditions whenever the species is divided into sections that do not intergenerate.

It should be observed that, in accordance with the principle of Intension, not only is indiscriminate Separate Generation when long continued transformed into more and more strongly Segregate Generation, but any form of Segregate Generation, resting on some one principle that causes the division of the species into sections differing in regard to some one form of endowment, will, if long continued, be inevitably reinforced and intensified by transformations, which, being independently combined and trans-

mitted, will multiply the number of characteristics in regard to which divergence takes place. If, for example, the pollen of a given variety, when falling upon the stigma of the same variety or race, is impotent over the pollen of any other variety or race that falls upon the same stigma at the same time, or at a somewhat earlier time, what I call Prepotential Segregation will divide the species into two groups that are prevented, for the most part, from intergenerating; and these separate groups, gradually coming under the influence of different degrees, forms, and combinations of the transforming principles, will in time become strongly characterized species. It is not, however, necessary that all or any of these forms of transformation should cooperate with Segregation in order to produce a distinct species. The accumulated effects of Segregation, unaided by these principles of transformation, would be sufficient to produce well-defined species; but it is impossible that they should often remain unaided.

As the law of Intension is one of the most general of the laws relating to divergent evolution, it is not strange that the principles through which it is made evident are of a general nature. The marvel is that concerning so wide a law the evidence is so complete.

Utilitarian and Non-Utilitarian Divergence.

The principles of Suetude and Selection are directly related to the development of utilitarian characters; but the effects of the other six principles are often not only wanting in, but opposed to, utility. Assimilational Transformation includes redundance of growth, which is not always, as well as economy of growth, which is always, utilitarian. Some of the inherited effects of Stimulation and Emotion fortify the constitution against the destructive influences of the environment, while others leave the offspring more exposed than the parent. Unbalanced Elimination, Amalgamation, and Fecundity may be advantageous, useless, or disadvantageous. We have, therefore, in these six principles of transformation abundant cause for the introduction of non-utilitarian characters; and, when accompanied by Independent Generation, they must be the source of multitudes of non-utilitarian divergences. In the earlier stages of divergent evolution the non-utilitarian distinctions are more abundant; for in the later stages multitudes of them are weeded out by economy of

growth (as has been clearly pointed out by Mr. Romanes *); and still others, through coming under new conditions in the environment or through some new habit of intelligence, become useful endowments, and are brought under the preserving and accumulating influence of Natural Selection or of Suetude. It should, however, be noted that the development of useful specific differences is as much due to Independent Generation as is the development of useless specific differences. Diversity of Suetude or of Selection does not produce divergent evolution unless it cooperates with Independent Generation.

Selectional Intension,
or *Segregation and Divergence produced by Independent Selection.*

That we may gain a clear apprehension of the nature and influence of this principle, certain discriminations, which have not always been recognized by writers on the subject, are absolutely necessary; and, for the sake of avoiding misunderstandings, it is desirable that these distinctions should be represented by clearly defined terms. I am fully aware that many will be opposed to the introduction of new terms into the treatment of a subject that has been so long and so ably discussed. If these discriminations were not found necessary by the author of the 'Origin of Species,' or if the distinctions, so far as recognized by himself and others, have been expressed in the language of ordinary description, why should a more accurate terminology be needed now? In reply, it may be said that the freedom from technical language which is a great advantage in a work which for the first time calls attention of the world to a vast subject, is a serious defect when the exact relations of the subject come under discussion.

In order to secure clear thinking on the subject, I have found it necessary to keep the following distinctions constantly in mind:—

(1) The Selection that results in the transformation of species is not the selection of one species to the exclusion of another. The breeding of the horse to the exclusion of the ass modifies neither the one nor the other. It is the exclusive generation of certain variations of a single intergenerating group that gradually

* "Physiological Selection," Journ. Linn. Soc., Zool. vol. xix. p. 383.

transforms the group. When, therefore, we speak of Selection as a cause of transformation, we refer to the Selection of the variations that are to interbreed and keep up the race, to the exclusion of other variations. In order to maintain the same distinction in the nomenclature of natural processes, what I call *Selection* is caused by the failure of certain forms of a species to perpetuate their kind as contrasted with the success of other forms. If the failure includes all the forms of a species, I call it the *Extinction* of that species, and class it as a cause of transformation in the remaining species only so far as it makes a change in their environment.

(2) The exclusive generation of certain forms of an intergenerating group does not necessarily result in transformation. Experiments in artificial breeding show that if we select only the typical representatives of a race, the general character of the race is not changed, though any tendency to fluctuating variation may be gradually diminished, and the stability of the type increased. When, however, one form of deviation from the mean is constantly selected without a counterbalancing selection of the opposite deviation, the transformation of the race is always the result. In other words, *Balanced Selection produces Stability of Type, and Unbalanced Selection produces Transformation of Type.*

In the light of this twofold law we see how there may be stringent Natural Selection without transforming effect. It has sometimes been maintained that the transformation of species through the Natural Selection of favoured races is a necessary process which must be operating in nearly every species; for in nearly every species there is a constant struggle between the different forms of variation; and as it never happens that all the forms are equally successful, the process of Natural Selection is always bearing in full force upon the species. If it could be shown that Natural Selection, wherever it exists, must necessarily produce transformation, it would be impossible to resist the conclusion that nearly every species is undergoing transformation through this cause. But it is Unbalanced, and never Balanced, Selection that produces transformation. We also see that heredity tends to make the most successful form the average form, and thus to convert Unbalanced into Balanced Selection. From this it follows that in order that Selection should pro-

duce continuous transformation, it is necessary that the form of variation selected should from time to time be changed. This may be expressed as the law of *Continuous Transformation through Successive Changes in the Character of the Selection.*

Though Selection produces transformation only when it involves the survival of other than typical forms, it is still very possible that there are but few species in which completely Balanced Selection prevails for very many generations in succession. It is still certain that long-continued Independent Selection gradually passes into diversity of Selection producing divergent evolution.

(3) Though in more than one passage Darwin maintains that uniformity of external conditions involves uniformity of Natural Selection, and that isolation can have no effect in transforming a species if physical conditions and surrounding organisms remain the same, still, I think, that if the question had been distinctly brought before him, he would have admitted that exposure to a new or changed environment was not a necessary condition for change in the character of Sexual Selection. Now I think it can be shown that, besides Sexual Selection, there are several forms of Selection that depend upon the relations of the members of one species to each other, and that may undergo change without the organism being exposed to either a changed or a different environment.

Selection depending on the relations of the organism to the environment I call *Environal Selection,* of which I find two kinds, namely:—Natural Selection and Artificial Selection. Selection depending on the relations of the members of a species to each other I call *Reflexive Selection,* the chief forms of which I call Conjunctional, Dominational, and Institutional Selection.

(4) It must be carefully noted that Diversity of Selection depending on diversity in the relations of the organism to the environment, does not necessarily involve the exposure of the organism to different environments. In other words, change even in Environal Selection does not necessarily involve either change in the environment or the entrance of the species into a new environment. It may be due to a change in the methods of appropriating the resources of the environment, introduced by the organism without any change in the environment. Darwin's teaching seems, at times, to be in conflict with this statement, but there are passages in his writings which distinctly state that

variations in instinct may lead to different habits of sustentation, and it is evident that, as soon as the qualities that win success in the different sections differ, the Natural Selection must differ.

It should be remembered, however, that the meaning of anyone's statements on this subject will depend on his definitions of the words used. What is meant by environment, external conditions, and other similar terms? Until we define we shall only beat the air, however exact our statements may be. I therefore repeat what I have elsewhere stated, that, according to my definition, change in the environment is always change in activities that lie outside of the species, or of the segregated group of individuals that is under consideration. In Darwin's usage, the phrase "Change in external conditions" seems to carry the same meaning; but in some places this can hardly be the case, and accordingly great obscurity hangs over some of his statements on the most important subjects.

Diversity in the uses to which different sections of one species put their powers, when appropriating resources from the same environment, must produce diversity in the forms of variation that are most successful in the different sections. This I call *Active Natural Selection* as contrasted with *Passive Natural Selection*, which varies according to differences in the environment. All diversities of Natural Selection that do not vary according to differences in the environment must be classed as diversities of Active Natural Selection, for they must have originated in some variation in the powers of the organism, or in the diversity of uses to which it has put its powers. Diversity in the successful use of the powers of the species, whether initiated by diversity in the action of the species in its different sections, or by diversity in the activities of the different environments, necessarily introduces diversity of Natural Selection. This principle may be expressed as the *Dependence of Diversity of Adaptational Selection on Diversity of Successful Use.*

(5) Now diversity in the successful use of its powers in the different sections of a species cannot be maintained and accumulated without some degree of Segregation between the different sections, for within one intergenerating group every initial divergence is speedily merged in the general character of the group. This law may be briefly defined as the *Dependence of*

Increasing Difference in the kinds of Adaptational Selection on the Continuance of Segeneration. As was shown in my paper on "Divergent Evolution through Cumulative Segregation," without the aid of causes preventing intercrossing the selection of other than average forms will produce *transformation*, but never *divergence*,—will produce Monotypic, but never Polytypic Evolution.

(6) Diversity in the character of the Selection may be introduced, not only by the intervention of new forms, but also by the cessation of old forms of Selection. We shall find that important differences of this kind may arise, resulting in considerable transformation before any new form of Selection has distinctly supervened. A good illustration of the *Cessation of Selection* is found in the increasing frequency with which human mothers, notwithstanding their failure to give suck, succeed in raising their children. The power to give suck is through this process being diminished in the more civilized races, though there is no reason to believe that those who do not give suck have, on the whole, any advantage over those who do. The new result is therefore being produced, not by the introduction of a new form of Filio-parental Selection, but by the cessation, or the weakening, of an old form. Romanes was, I believe, the first to point out the effects that must often be produced by the cessation of Natural Selection *, but he has not considered the cessation of other forms of Selection.

(7) It is often convenient to distinguish between Selection resulting from rational devices and that resulting from the superior success of organisms better adapted than their rivals of the same intergenerant to the natural laws and conditions of the environment, or to the natural constitution of the species to which they belong. The former I call *Rational Selection*, and the latter *Adaptational Selection*. Under the former I place Artificial and Institutional Selection, and under the latter I place processes that are as unlike as Natural and Sexual Selection. This classification does not, however, seem to me so important, or so fundamental and clearly definable, as that which

* See an article on "The Factors of Organic Evolution" in 'Nature,' vol. xxxvi. pp. 402–404, in which reference is made to previous papers in which the Cessation of Natural Selection is discussed.

rests on the fact that some forms of Selection depend on the relations in which organisms stand to the environment, while others depend on the relations in which the members of the same species stand to each other. It may here be noted that Artificial Selection is the exclusive generation of those that are better fitted to the rational environment, through the failure to propagate of those that are less fitted. The effect is the same whether the failure to propagate is through lack of adaptation to human purposes, or through lack of adaptation to the unreasoning environment. Natural Selection is propagation according to adaptation to the Natural environment, and Artificial Selection is propagation according to adaptation to the Rational environment.

(8) Another discrimination which I have found it convenient to make, is that between Comparative and Superlative Selection. *Comparative Natural Selection* is the direct result of varying degrees of adaptation to the environment, without the additional influence of rivalry between the members of the same species. It is propagation of the fitted, according to the degrees of their fitness, controlling the expansion of a species before its members crowd and supplant one another. *Superlative Natural Selection* arises from the competition of members of the same species for the possession of identical resources, and results in the survival of those only that are most perfectly fitted to the environment. Comparative Selection is the Survival of the Fitted—of all the fitted, according to their degrees of fitness; Superlative Selection is the Survival of the Fittest—of only those who through superlative fitness can, in a crowded community, find the sustenance and other conditions necessary for perpetuating their kind.

The following classification (p. 329) of the forms of Selection will, I think, be a help in maintaining these and other distinctions.

FORMS OF SELECTION.

	ADAPTATIONAL SELECTION.	RATIONAL SELECTION.
ENVIRONAL SELECTION.	*Natural Selection.* Balanced. Unbalanced. Active. Passive. Comparative. Superlative.	*Artificial Selection.* Balanced. Unbalanced. Active. Passive. Comparative. Superlative.
REFLEXIVE SELECTION.	*Conjunctional Selection.* Balanced. Unbalanced. Sexual. Social. Filio-parental. Comparative. Superlative. *Dominational Selection.* Balanced. Unbalanced. Sustentational Domination. Protectional Domination. Nidificational Domination. Nuptial Domination.	*Institutional Selection.* Balanced. Unbalanced. Ecclesiastical. Military. Sanitary. Penal. Comparative. Superlative.

Natural Selection.—As Natural Selection involves not only the superior propagation of the better fitted, but the inferior propagation of the less fitted, and the non-propagation of the least fitted, it may be described as the *Exclusive propagation of those better fitted to the natural environment, through the failure to propagate of the less fitted.* Transformation by means of Natural Selection depends on varying degrees of adaptation to the environment in creatures that are intergenerating, the higher degrees being possessed by other than average forms. Divergence is produced by Natural Selection only when to the above conditions producing transformation are added causes that prevent intercrossing between the sections that are being inde-

pendently transformed. In other words, *Independent Natural Selection produces Divergence.*

Sexual Selection is the exclusive propagation of those better fitted to the sexual constitution of the species through the failure to propagate of the less fitted. In the words of Darwin, "It depends on the advantage which certain individuals have over others of the same sex and species solely in respect of reproduction." * It is the form of Reflexive Selection which has received Darwin's attention, and is consequently familiar to all. There are, however, certain points that need to be emphasized.

This is the principle in accordance with which correspondence is secured between the external characteristics and the sexual instincts of a species, and also between the instincts of the two sexes, in as far as they relate to reproduction. This result is secured partly by the failure to propagate of those whose powers of attraction and conquest do not reach the standard demanded by the instincts of the other sex, and partly by the failure of those whose instincts diverge too widely from the typical characteristics of the other sex. For example, on the highlands of North China I have observed a species of creeping cricket of the genus *Bradyphorus*, the male of which calls the female by a sharp stridulation, to which the female responds by approaching the male and finally climbing upon his back. Now we can well understand that the call of the male has been brought to its present shrill, penetrating perfection through the failure to attract mates in the case of males that were but feebly endowed; but it is equally certain that those females whose sluggish instincts have been capable of responding only to an unusually intense call have, for the most part, failed of leaving offspring, and, if any have been so unreasonable as to wait for the male to seek them out, they have, doubtless, perished without perpetuating their perverted instincts. If my view is correct, the change producing divergent sexual characteristics may be either in the instinct, or in the characters with which the instinct is correlated. It seems probable that in the vast majority of cases the more strongly divergent forms have been reached by a multitude of deviations alternating between the psychical and the physiolo-

* 'Descent of Man,' 3rd page of Chap. VIII.

gical and morphological characters of the species, the chief, indispensable condition being the prevention of interbreeding between the diverging sections of the species.

Sexual Selection is sometimes referred to as if it were the influence of sexual instincts in giving character to the organs of a given sex, first by the instincts of the same sex rousing the organs to successful activity in securing propagation, the degree of success depending on the degree of adaptation of the organ to the purpose of the activity (as in the case of barnyard cocks winning partners by the use of their spurs), and, second, by the instincts of the opposite sex being roused to successful action according as the endowments of the given sex are fitted to the end (as in the case of peacocks winning partners by the display of ornamentation). Starting, however, with this conception of the nature of Sexual Selection, we shall find great difficulty in obtaining from the principle any explanation of the origin of species, or of divergent evolution of any kind. If divergent instincts are the causes of divergent forms, colours, and qualities, what are the causes of the transformation of the instincts in lines that are persistently divergent? The problems of transformation and divergence are as far from solution after the application of the theory as before.

If, on the other hand, we recognize Sexual Selection as the harmonizing of the forms, colours, and qualities of a species with its sexual instincts, and of the sexual instincts with its forms, colours, and qualities, we shall not claim that either set of characters is directly and continuously the cause of transformation in the other; but rather that the two sets play upon each other in such a way as to produce a state of unstable equilibrium in both sets, the result of which is indefinite transformation in the secondary sexual characters of each section of a species that constitutes a separate intergenerant; and that the Independent Transformation inevitably results in Divergence. In Darwin's presentation of the principle of Sexual Selection, the chief endeavour is to show that differences in voice and ornamentation between the males and females of the same species are probably, in a large degree, due to diversity in the action of Sexual Selection upon the different sexes; but this is a very different result from differences in the same respects between those of the same sex in closely allied varieties and species; and no clear

understanding of the subject will ever be reached till those who study and discuss the subject discriminate between these two classes of phenomena. The formation of differences of the former kind is simple transformation without divergence, while the entrance of differences of the latter kind is divergent evolution tending to the production of separate species.

If a species deficient in secondary sexual distinctions, after being divided into segregated sections, attains a high development of such distinctions, it is easy to believe that they will be developed in different ways in the different sections, and that thus they will become specific distinctions; but it is not so easy to see why a species in which sexual distinctions have already been fully developed should undergo divergent changes in the different sections into which it may be divided. It is in such cases that we discover the important influence of what I have called unstable equilibrium. It seems probable that in some cases small differences originating through indefinite variation in only a few isolated individuals are seized upon by the exaggerating fancies of the other sex, and are thus first preserved through isolation and then exaggerated by Sexual Selection. In other words, *Independent Sexual Selection produces Segregation and Divergence.*

Social Selection is the exclusive breeding of those better fitted to the social constitution and instincts of the race through the failure to breed of those less fitted. Social organization has reference chiefly to co-operation in securing sustentation and defence. If for each species there were but one possible form of social organization through which sustentation could be secured, there would be no need of considering Social Selection, for the form of social organization would be rigorously determined by Natural Selection, and the success of the individual through conformity to that organization would be sufficiently explained by the principle of Natural Selection. But different forms of social organization are often exhibited by the same or closely allied species; and we find that, in such cases as elsewhere, the prosperity of the individual is largely dependent on his conformity to the social organization to which he belongs. Social Selection must, therefore, in some cases have been an important factor in maintaining a correspondence between the capacities and the social organization of a race or species. When a species

or a section of a species is undergoing a change of social habits, there will be individuals that fail through reverting to the old instincts and methods which put them out of accord with the rest of the community. But through the failure of these the inherited instincts of the race are brought into increasing accord with the new habits till, in the case of most species, there are but few individuals that fail through lack of appropriate social instincts. Nevertheless in the branches of the human species that have attained the highest civilization the process is still far from complete, for the instincts of many individuals are in conflict with civilized habits.

We find that the natural faculties that are best fitted to secure individual success, and a numerous and long-continued descent, are different under different forms of civilization. Social habits in a great measure determine the food and clothing of a community, and thus deeply affect the qualities of the race. The exposure to which the young are subjected is also largely determined by social custom, and so the quality of the constitution that is permitted to survive. In other words, the form of Parental Selection that prevails in any community is often determined by Social Selection, as the form of Social Selection is sometimes determined by Natural Selection. Many matters, which amongst irrational animals are determined by instincts guiding the individual directly to the needed resources and showing what provision must be made, are with man determined by social instincts leading the individual to follow the general experience or traditional habits of his clan.

As in countries where there are no beasts of prey the gregarious instinct of cattle ceased to be a necessity for the preservation of life, it is no longer maintained by Natural Selection, but it may be preserved by Social Selection; for though occasional stragglers appear, they are, through lack of adaptation to the social organization, specially liable to fail of finding mates, and therefore to fail of propagating their kind. Between the capacities of a community and its social organization there is a constant action and reaction which tends with more or less rapidity toward transformation; and this tendency is increased when a small community, during a long separation from other communities, gradually increases in strength, independently constructing a civilization of its own. In other words, *Independent*

Social Selection tends toward divergent evolution of capacities and of social organization.

Filio-parental Selection is the exclusive breeding of those better adapted to the relations in which parents and offspring stand to each other, through the failure to live and propagate of those less adapted. How the power of giving suck and the corresponding instinct for sucking were first developed it may be impossible to tell; but it is evident that having once been established as the method of sustentation for the young of mammals, any young lacking the instinct would perish without leaving descent. There is every reason to believe that, with the exception of man, it may be truly said of every individual mammal that all its ancestry, through all its generations that have elapsed since they became fairly mammalian, have had this instinct in full force; and yet it sometimes fails, and the line of descent is cut short. Till comparatively recent times the same was true of man; but we now find some cases in which the young survive in spite of their inability to suck, and the constancy of this mammalian characteristic is being gradually impaired. There is also in some races an increasing tendency to shorter periods of lactation, or to the entire suppression of the function; so that it seems not improbable that there may yet arise a variety of the human species in which the power will be comparatively obsolete. Under such conditions the instinct for sucking would cease to be of any advantage, while special advantage would accrue to those best able to thrive on the artificial food habitually provided by the parents. In some countries this would be the milk of ruminating animals, while in other countries it would be some vegetable preparation. In the islands of Micronesia it is the sap that exudes from the cut end of the immature fruit-stalk of the cocoa-nut tree. In Japan it is a sweet extract of malt. Through this diversity in the food provided by parents for their infants and small children, there is even now a constant diversity in the Parental Selection prevailing in different countries. Diversity in the forms of Parental Selection is also produced by diversity in the clothing and artificial heat provided by parents, in the protection, on the one hand, of children from the wind and rain and direct rays of the sun, and, on the other hand, their exposure to the same with shaven heads or naked bodies, and in the methods of binding, cramping, and mutilating the head, feet, waist, and other parts of the body. From

this point of view we see how largely the form of Parental Selection is determined by social custom, and how it is sometimes enforced by Social Selection, which excludes from the benefits of the caste or tribe all who have not been through the ordeal.

As Filio-parental Selection is due to different degrees of adaptation between the parent and offspring, it may be characterized not only by fatal departures in offspring from the characters required in their relations to their parents, but by fatal departures in parents from the characters required in parents in their relations to their offspring. As an example of the former, we may refer to the death at birth of children with excessively large heads; and as an example of the latter, to the death at birth of all the children of a mother with a contracted pelvis.

Dominational Selection.—Variations that are equally fitted to cope with the environment may be divided into two classes—those better able, and those less able, to cope with other members of the species in appropriating resources. Increase of population and the consequent competition between members of the same species condemns the latter to premature death, or at least to failure in propagating, unless they find new resources by migrating or by changing their habits. Competition between kindred for the possession of identical resources we find directly connected with three quite distinct principles of evolution:—(1) With the principle of *Superlative Selection* tending to the destruction of all forms except those most fully adapted to the environment; (2) With the principle of *Dominational Selection* tending to discriminate between those equally adapted to the environment, through the success and consequent propagation of those only that are best able to cope with their kindred in appropriating advantages; (3) With the principle of *Competitive Disruption*, tending to break up old relations and old habits, and so preparing the way for the formation of new habits producing segregation and divergence. Of these three principles, the last was referred to in the second chapter of my paper on "Divergent Evolution through Cumulative Segregation," p. 221, and the first has already been mentioned in this paper. The remaining one I shall here briefly describe, without attempting to show its important influence on the transformation and divergence of species.

Dominational Selection is the exclusive breeding of those better able to appropriate natural resources, or mates, or the provision

made by parents or society, not through being better fitted to the environment or to the organized methods of co-operation and assistance, but through being better able to overcome or outdo their rivals of the same species. It results from the contest or rivalry with each other of members of the same species that are equally fitted to the environment and to the constitution of the species, and the consequent failure of all that are not able to cope with their kindred. "The law of battle" is a form of Dominational Selection which Darwin emphasizes as having great influence in determining what males shall have the best success in procuring mates. But there is a similar law determining what individuals shall obtain the resources furnished by nature, or elaborated by parents and society. We may have Dominational Selection relating to sustentation, protection, and nidification, as well as to the possession of females. And in gaining a single end there may be a great variety of dominating methods. Combat between males for the possession of females is not found in the vegetable kingdom; but the prepotence of the pollen of certain flowers over that of other flowers of the same race may play a similar rôle.

Dominational Selection differs from Natural Selection in that it does not depend on degrees of adaptation to the environment, and from other forms of Reflexive Selection in that it depends on a quite distinct form of the relationship in which members of the same species stand to each other. It seems desirable that this form of selection, which depends on adaptation for overcoming, outdoing, or supplanting others of the same species, should be clearly distinguished and named. We further note that there can be no doubt that Dominational Selection acting for many generations on sections of a species that are prevented from intercrossing will in all probability follow somewhat different lines. In other words, *Independent Dominational Selection will produce divergent evolution.*

Institutional Selection is a form of exclusive breeding closely related to Social Selection, but differing from it very much as Artificial Selection differs from Natural Selection. Institutional Selection is the influence of institutions, customs, and laws in determining what classes of individuals have an opportunity to marry and raise children. In most civilized countries criminals convicted of important offences are so confined as to prevent their adding to the population of the community during the time of

their confinement. This is a method of improving the race that might be carried further than it has been. In some countries the insane are confined in asylums and not allowed to marry; and in other countries ecclesiastical and military restrictions prevent certain portions of the community from raising families.

Result of the foregoing Survey of Selectional Intension.

The analysis which we have now completed enables us to see how far changes in the form of Selection are due to changes in the environment, and how far to changes in the organism. We find:—First, that all the forms of Reflexive Selection are due to the relations of members of the same species to each other, and are liable to change without any change in the environments. Second, that Active Natural Selection is due to change in the successful use of the powers of the organism in dealing with the environment, and is not dependent on change in the environment. Third, that Passive Natural Selection, which is due to the exposure of the organism to a different environment, is often produced by the organism's entering a new environment without there being any change in either the new or the old environment. Fourth, that when Passive Natural Selection is produced by change in the environment, the more effective forms of Selection do not appear till the organism has so multiplied as to produce what I call Superlative Natural Selection through intense competition between rival individuals of the same species in gaining possession of limited resources. And, fifth, that Passive Comparative Natural Selection, which depends on change in the environment, without special rivalry between the members of one species, also depends on variation in the adaptations of the organism, many of which variations do not depend on that change in the environment which has produced the change in the Natural Selection, nor, indeed, on any change in the environment except those fundamental physical changes by which the world has passed from its primitive gaseous to its present partially liquid and solid state, rendering it a fit abode for organisms.

Eliminational Intension.

Eliminational Intension is Segregation and divergence produced by the indiscriminate destruction or failure to propagate of part of the individuals of similar sections of a species. Though

indiscriminate destruction cannot be classed as a form of Natural Selection, it may nevertheless be the cause of transformation; and when a species is distributed in sections that are prevented from intergenerating, divergent evolution will often be hastened by the indiscriminate destruction of part of the members of one or more of the sections. If a species inhabiting a large island is divided by geological subsidence into two equal sections, there may be a very close resemblance in the average character of the two sections; but if a subsequent eruption of hot ashes destroys a large portion of the individuals of one section, or of both, the probability of a close correspondence in the average character of the two sections will be very much less than before the eruption.

Again, when an area occupied by a species is divided into two or more equal districts, the occupants of which can have little or no opportunity for crossing, divergent evolution will arise in the different districts unless there is some constantly operating cause that ensures all the varieties that survive and propagate in any district shall survive and propagate in all the districts. No such cause has ever been pointed out; but, on the contrary, it can easily be shown that the probability is very small that such a correspondence would occur, even if at the time of the division of the area every individual in each district was represented by a completely similar individual in each of the other districts. Let us suppose a case:—

1. Suppose the creatures under consideration to be a species of mollusk, the sexual instincts of which act without any segregative tendency between the varieties of the same species, there being no aversion or other impediment that interferes with the free crossing of all the variations occurring within the limits of one district.

2. Suppose that the number of individuals in each district is 10,000,000.

3. Suppose that one in a thousand of these had a tongue strong enough to feed on the bark of the tree, the leaves of which are the ordinary food of the species, and that one in a thousand is capable of digesting the same, so that, in each district alike, one in a million could survive in this way though the crop of leaves should fail.

4. Suppose that there are, through diversity of adaptations of this kind to the products of the environment, ten different kinds

of accessible forms of food, on each kind of which one in a million of the individuals of each district might feed if driven by necessity.

5. Now suppose the same necessity should occur in each district through the destruction of the leaves on which they habitually feed; and that there are accordingly in each district a hundred survivors able to maintain themselves on other kinds of food.

Under such circumstances (the correspondences of which we have in our supposition made much more exact than the actual deviations from a mean ever present)—but even under such circumstances of completely parallel variation—what is the probability that in each of the separate districts the few that would meet with other individuals and have an opportunity to propagate the species would be similarly endowed and similarly related to the environment?

In order to still further simplify the problem, let us assume that in the case of each kind in each district the probability that it will succeed in propagating is exactly balanced by the probability that it will fail. The probability, then, that any given number of the ten kinds in a given district will succeed is found by estimating the number of combinations that can be secured by taking that number of things out of ten things in different ways. This is completely parallel to the number of ways in which ten pennies can be arranged as to head and tail, each penny representing one form of variation, and its lying head-up indicating success in propagating. In 1024 experiments the probability is

That 0 will succeed	....		1 time
„ 1 „ „	$\frac{10}{1}$	=	10 times
„ 2 „ „	$\frac{10\times9}{1\times2}$	=	45 „
„ 3 „ „	$\frac{10\times9\times8}{1\times2\times3}$	=	120 „
„ 4 „ „	$\frac{10\times9\times8\times7}{1\times2\times3\times4}$	=	210 „
„ 5 „ „	....		252 „
„ 6 „ „	....		210 „
„ 7 „ „	....		120 „
„ 8 „ „	....		45 „
„ 9 „ „	....		10 „
„ 10 „ „	....		1 „

These figures are found in the eleventh line of what is known as the "Table of the Binomial Coefficients," or the "Arithmetical Triangle"*. And so in the case of any number of objects, the number of combinations that may be made with n objects is found in the $n+1$th line of the Arithmetical Triangle classified according as there are 0, 1, 2, 3, or more objects in each combination. The whole number of combinations may also be found by calculating the nth power of 2.

The possible combinations of the ten varieties in question are 1024, which is equal to 2 raised to the 10th power; the probability, therefore, that the combination that succeeds in one district will also succeed in the other district is $\frac{1}{1024}$, or 1 in 1024; while the probability that those that succeed in the one district will not be all the same as in the other will be $\frac{1023}{1024}$, or 1023 in 1024, which is more than a thousand times greater than the reverse probability.

These 1024 different results, any one of which may occur in one section, are calculated on the supposition that all the representatives of the species in one section that succeed in propagating will in time coalesce by intercrossing; but, as we shall presently see, the number of divergences in the two sections may be vastly increased by the diversity of ways in which the same varieties may be combined through the greater or less influence of minor segregations within the bounds of each district.

Amalgamational Intension.

In my paper on "Divergent Evolution though Cumulative Segregation," p. 233, I have referred to the fact that the vast majority of divergent forms produced by Segregation, after existing for a time, are interfused with competing forms of the same species. Now it is evident that when a permanent Segregation arises, if in the separate sections there is a diversity of amalgamations between the slightly divergent forms produced by partial segregations, the results will be divergent in these separate sections. That there will be diversity in this respect, we may argue: first, from the improbability that all the varieties in one section will occur in each of the other sections; second, from the improbability that if the same varieties occur in each section, they will occur in the same proportions; and, third, from the improbability that if they are the same and in the same

* See 'Principles of Science,' by W. S. Jevons.

proportions, they will break over their barriers and interfere with each other in precisely the same way in each section. Amalgamational Intension relates only to the last point. The other two points have been discussed under the principle that Separation always involves more or less Segregation (see the third paragraph of this paper).

Taking up again the supposed case considered under Eliminational Intension, if the different kinds of new food were so situated as to make it more or less difficult for those feeding on one kind to cross with those feeding on other kinds, the representatives of the species in each of the completely separated districts would be divided into minor segregations of a partial kind; and the different degrees of intercrossing between the minor segregations in the separate districts would be an additional cause of divergence, which we may appropriately class as a form of Amalgamational Intension. Occasional interchange of stations by the varieties in one district would produce a degree of homogeneity in the forms of one district that would not be found when comparing those of different districts; but as the degrees of intercrossing between any two or more identical varieties that might happen to be preserved in both districts would, in all probability, differ in the different districts, the correspondence that at first existed between certain portions of the two sections would gradually disappear. We shall find that in order to ascertain with facility the number of different sets of combinations in which any given number of varieties may be combined while all are propagating, and the probability that any given degree of correspondence will present itself in any two sets of combinations that may be taken at random, we need a table by which the number of permutations that may be made with given numbers of things may be analyzed. I have constructed such a table, which I call the Permutational Triangle *, with the aid of which the solutions of problems that would otherwise require much time are easily reached.

Returning to the above calculation, we observe that in 1024 experiments, under the circumstances there assumed, there would probably be but one occasion in which, out of the ten identical varieties which were assumed to occur in each district, the same varieties would succeed in propagating in each district. We

* I give in an Appendix this Permutational Triangle, calculated to the tenth line, with an explanation of how it was formed.

have now to consider the degree of probability that these identical varieties will make the same combinations with each other in the different districts. I shall not attempt to give a complete answer; but by carrying the computation through several steps, I shall sufficiently exhibit the extreme improbability that, even when identical varieties succeed in propagating in the different districts, they will combine with each other in the same way and in the same proportions.

As in the case of the 10 varieties that have been under consideration, 5 is more likely to be the number of varieties that succeed than any other number, 5 is most likely to be the number of successful varieties in each district when the varieties happen to be the same in each district; and we will therefore begin with that number. If, now, we suppose that there are 5 varieties in each district, and that there is the same chance in the case of each variety that it will breed with any one of the other varieties, as there is that it will be segregated and breed by itself, we shall find that in 120 experiments there will probably be 1 occasion in which all the varieties of one of the districts will be segregated from each other, and 10 occasions in which three of the varieties will be segregated, and 20 occasions in which two will be segregated, and 45 occasions in which one will be segregated, and 44 occasions in which none will be segregated *. These probabilities are expressed by the fractions $\frac{1}{120}$, $\frac{10}{120}$, $\frac{20}{120}$, $\frac{45}{120}$, and $\frac{44}{120}$. And the probability that the same varieties will be intercrossed and the same ones segregated in each district is $\frac{1}{120}$; while the probability that some one particular set of segregations and intercrossings that is designated in advance will occur in both districts is $(\frac{1}{120})^2$. For example, the probability that all the 5 varieties in one district will be segregated is $\frac{1}{120}$; and the probability that all in both districts will at the same time be segregated is $(\frac{1}{120})^2$.

But the two districts may correspond by the complete failure of all varieties to propagate, in which case they will continue to correspond. Again, there may be but one variety in each district that succeeds in propagating, and that the same, in which case there will be no chance for diversity of Amalgamation in the different districts, at least not before a diversity of subordinate segregations has first arisen. Again, if the same two varieties

* These figures are found in the 5th line of the Permutational Triangle. See Appendix.

succeed in propagating in each district, the probability of complete correspondence in integration will be as 1 to the factorial of 2, or as $\frac{1}{1\times 2} = \frac{1}{2}$;

if the same 3 varieties, the probability $= \frac{1}{1\times 2\times 3} = \frac{1}{6}$;

" " 4, the probability $= \frac{1}{1\times 2\times 3\times 4} = \frac{1}{24}$;

" " 5, " $= \frac{1}{1\times 2\times 3\times 4\times 5} = \frac{1}{120}$;

" " 6, " $= \frac{1}{720}$;

" " 7, " $= \frac{1}{5,040}$;

" " 8, " $= \frac{1}{40,320}$;

" " 9, " $= \frac{1}{362,880}$;

" " 10, " $= \frac{1}{3,628,800}$.

These fractions represent the probability of complete correspondence as to the varieties that intercross and those that remain segregated in the different districts when the same varieties occur in each district; and the squares of these fractions represent the probability that any special combination that may be indicated will occur in both districts at the same time. If there are, for example, the same ten varieties in each district, the probability that they will combine in the same way is $\frac{1}{3,628,800}$, and the probability that this way will be the breeding of each variety with its own kind, without any intercrossing, will be $\left(\frac{1}{3,628,800}\right)^2$. But there may be degrees of correspondence in the combinations of different districts. As we have just seen, the probability that there will be correspondence in ten points is $\frac{1}{3,628,800}$, that there will be in eight points is $\frac{45}{3,628,800}$, that there will be in but one point is $\frac{1,334,960}{3,628,800}$, while the probability that there will be no correspondence is $\frac{1,334,961}{3,628,800}$ *.

We have thus far considered only the divergences that come

* The denominator of these fractions is the factorial of ten, that is $1\times 2\times 3\times 4\times 5\times 6\times 7\times 8\times 9\times 10$, and the numerators are found in the tenth line of the Permutational Triangle. See Appendix.

from a diversity of binary combinations coexisting with segregated varieties; but it is evident that the number of divergent arrangements that may be produced by any given number of varieties exceeding two will be much larger if to the above arrangements are added all that may be produced by arranging single with trinary, and binary with trinary; and if more complex combinations are introduced, the number may be still further increased.

Of the five suppositions with which we started*, the second and third assume a uniformity in the contingencies relating to the number and character of the individuals never realized in the different sections of a species that is divided by natural barriers; and the fifth assumes a uniformity in the changes affecting the environment which, though not often realized, is here assumed for the sake of showing that divergence of character is not dependent on the organism being exposed to different environments. In connection with the fourth supposition, it would have been in accordance with the usual conditions of nature to have assumed that, besides the many kinds of food of which only a very small fraction of the species could avail themselves, there would be a few kinds on which much larger numbers could feed; and that when the numbers that could partake of one kind of food were sufficient to ensure the propagation of those thus adapted, that variety would survive in both districts. But such certainty relating to the propagation of some of the varieties would not prevent the contingencies and the divergences that would arise in the propagation of the much rarer or less favoured varieties. It is also evident that similar contingencies would arise whenever the pressure of population on the supply of food should render it necessary for large numbers to seek new resources. The divergent tendency of such pressure, from whatever cause the pressure arises, is in no respect an arbitrary supposition; and the arbitrary assumptions which I have introduced in order to simplify the problem remove from consideration some of the contingencies that must produce still greater divergence.

Fecundal Intension,

or *Segregation and Divergence produced by Independent Fecundal Transformation*, that is by different relative degrees of fertility

* See page 338 of this paper.

possessed by the same forms of variation in separate sections of the species.—Relative Fecundity is propagation according to degrees of fertility. As it involves not only the superior propagation of the more fertile, but the inferior propagation of the less fertile and the non-propagation of the least fertile, it may be described as the exclusive propagation of the more fertile, through the failure to propagate of the less fertile. It would avail nothing in determining the form that is to prevail in succeeding generations if it did not in some degree preclude the crossing of the less fertile with the more; but, as it is evident that, so long as increased fertility is not a disadvantage, the more fertile half of the species will leave a larger number of offspring than the less fertile half, it follows that when the offspring have come to maturity a larger portion of the fertile will consort with the fertile than in the previous generation, and so the fertility of the following generation will be still further increased. The chief check to this law of *Cumulative Fertility* is found in the antagonistic law of Cumulative Adaptation through Adaptational Selection. The combined action of these two laws results in the triumphant development of the most fertile of the best fitted, or the best fitted of the most fertile.

Another result from the combined action of these two laws is that in species that are well adjusted to the environment the typical, that is the average, form of the species is not only the best adapted, but it is the most fertile; and this correlation between fertility and adaptation in the average form of the species or race is a strongly conservative principle, tending to prevent the rapid transformation of the race or species. Giants, dwarfs, and extreme departures from the type of other kinds are more likely to be sterile than the typical form of the species; and therefore if, through change in the environment or in the social conditions, some extreme form has an advantage in gaining subsistence, it will usually fail of propagating its kind with the relative rapidity of the less-favoured average form. This is at present true of highly intellectual variations of civilized man. Those of moderate capacities are more prolific, and accordingly persist, though less successful in other respects than the intellectual. But so long as the most successful individuals are those surpassing the average in intellectual endowment, so long will the average endowment be more or less steadily advancing; for, of intellectual families, those that are fairly fertile will leave more impress on

succeeding generations than those that are sterile; and of fertile families, those that are above the average in intellect will have the best success in leaving descendants to inherit their endowments.

Combined Influence of these Principles.

We have not at present sufficient knowledge of the influence of each of the principles of transformation to enable us to estimate their comparative importance; but we know enough of their combined action to anticipate with confidence that wherever Separate or Segregate Generation arises, producing more or less divergence, there these principles will in time intensify the result. The transformations and divergences of nature are produced by the interplay of numerous factors most intimately combined, and though for the purpose of comprehending the process we are compelled to study each principle by itself, we must remember that in nature they not only combine, but combine in a vast variety of ways. There is, however, reason to believe that species sometimes become so devoid of plasticity that all transformation is precluded, and, if the environment is changed, even in the most gradual manner, extinction is the result.

Divergent Evolution in the Land-Mollusks of Oahu.

Oahu is one of the Sandwich Islands, or Hawaiian Islands as they are now usually called. It is of volcanic origin, but the two mountain-ranges, which lie one on the north-east and the other on the south-west side of the island, show no signs of recent volcanic action. Unlike the mountains of Hawaii and East Maui, their sides are very deeply furrowed by the action of water, and their forests are not broken by flows of lava. The forests of the island cover these two ranges, forming two disconnected strips, the one about 36 and the other about 18 miles in length. In these forests are found 600 or 700 varieties, representing over 200 species, belonging to 7 subgenera, of the subfamily *Achatinellinæ.*

Two of these subgenera, *Amastra* and *Leptachatina*, are, for the most part, found under the dead leaves of trees in damp places; and one, *Laminella*, is found chiefly on low shrubs, while the remaining four are always found on trees or shrubs. Now it must be remembered that the climate is tropical, and that the

rainfall is so distributed through the year that in the shady groves there is nothing to drive the arboreal species from their haunts on the leaves or branches of the trees. Still further, as this branch of the Helicidæ, unlike most other branches, produces its young, not from eggs, but in a living active form, there is no occasion in its life-history that requires it to leave the tree in which it lives from generation to generation. In the distribution and divergences of these varieties and species we learn the following lessons :—

1. *Varieties are incipient species, and species are strongly pronounced varieties.*

A full collection of the varieties and species of any polymorphic genus produces an oppressive sense of confusion on the mind of any one who examines it for the first time. This is preeminently true of a full collection of the *Achatinellinæ* of the island of Oahu. Seven genera or subgenera are represented by a multitude of varieties and species, which, within the limits of each genus, are, for the most part, completely intergraded with each other. As natural selection has not removed the intermediate forms, it is impossible to say where a species begins and where it ends. Having selected a given form as the type of a given arboreal species, we soon find that it inhabits perhaps only one or two valleys, say half a mile in width, and only one, two, or three miles in length. Beyond these limits it is represented by varieties that become more divergent as the distance from the home of the type increases ; and, in the case of *Achatinella* and *Bulimella*, this divergence is so rapid that at the distance of 8 or 10 miles every one will admit that the forms all belong to different species. Indeed, in many cases, though the same vegetation is present, the habits of feeding have changed, while in other cases the form has changed while the habits remain essentially the same.

Though it is easy to find degrees of divergence which most naturalists will agree in calling specific, but which in a full collection are shown to be completely intergraded, yet if a full collection of the different forms should be submitted in succession to a hundred different naturalists to classify, it would be found that no two would agree as to the number of species; and a still greater diversity of opinion would be revealed as to where the limits of the different species should be placed. This is exactly what we might expect if varieties are incipient species, and species

are simply more strongly developed varieties. Such being the case, it is folly to ask that the nomenclature should be based on some fundamental distinction between species and varieties.

The best nomenclature is the one in which the specific distinctions correspond in degree with those that are recognized as specific in other families, and in which a degree of divergence that is considered specific in one part of a genus is considered specific in every part. If the distinctions on which Reeve, Pfeiffer, and Newcomb have founded the species in Makiki and Manoa are received as specific distinctions, then similar distinctions occurring in the forms of other valleys must be recognized as belonging to different species. I by no means contend that these differences should be regarded as specific; but having received the three or four forms of *Achatinella* found in Manoa as good species, it will not do to say that the three forms of *Achatinella* found in Waialei, differing from each other in the same way, are but one species.

Notwithstanding the diversity of opinion that will always exist as to how many species should be made of the forms occurring in any one valley, every one will agree that the forms of *Bulimella* and *Achatinella* found in any one valley are quite distinct species from those found in valleys that are ten or twenty miles distant. The lessons we are drawing from the divergences in this family are therefore not dependent on any special views concerning the number of species that ought to be received.

As examples of intergrading species, examine first the types of *Achatinella producta*, *A. adusta*, and *A. Buddii* from Makiki; then all the forms of these and the other species of *Achatinella* found in Makiki; and then the forms found in the successive valleys of the whole mountain-range.

If freedom from intergrading is received as the necessary and sufficient test of good species, then a multitude of forms that are now only varieties may be turned into good species by burning the forests in alternate valleys on either side of this mountain-range. Moreover, if this is the true test of species, the species-maker who throws intergade forms into the fire is quite consistent, even if not quite frank.

Whether we call these divergent forms species or varieties, the process by which the divergence has been produced is a matter of equal interest. Indeed, some evolutionists maintain that one of the chief desiderata in the theory of evolution is an explanation

of the origin of varieties *. Variations are deviations from the average, but varieties are groups of individuals in which the averages differ, and in which the inheritable characters differ. Still further, it is usually admitted that the divergences presented by varieties are not always essential to the well-being of the forms that possess them, and that in many cases the forms that are confined to separate localities might exchange positions without suffering disadvantage. Divergence in these initial stages has seemed to many to be an obscurer problem than the advancing usefulness which sometimes entirely remodels an organ. For, as Prof. Le Conte has said, "Natural selection does not make an organ useful, but only more useful."

I believe that the theory of divergent evolution, presented in this and the preceding paper, is applicable to the formation of divergences during the stage when some of the differences, if not all, bring neither advantage nor disadvantage to those that possess them. Whatever we call these divergent forms, can we give any explanation of the causes that have produced them?

2. *Divergent Evolution does not necessarily depend on either change in or change of the environment.*

In other words, it does not necessarily depend on change in the conditions surrounding the organism, or on the organism being brought into a district presenting a different set of conditions.

Darwin maintains that isolation (that is geographical separation), without any differences in the surrounding organisms or in the physical conditions, presents no occasion for divergence of character. He says, "If a number of species, after having long competed with each other in their old home, were to migrate in a body into a new and afterwards isolated country, they would be little liable to modification" ('Origin of Species,' 6th ed. p. 319).

Spencer expresses the same idea by saying that "Vital actions remain constant so long as the external actions to which they correspond remain constant" †. "There must be maintained a

* See 'Evolution and its Relations to Religious Thought,' by Joseph Le Conte, published by Appleton & Co., page 252.

† Though apparently opposed to his theory of "the production of certain local forms by amixia," this same idea is found in Weismann's 'Studies in the Theory of Descent,' pp. 109-115 (English edition).

tolerably uniform species so long as there continues a tolerably uniform set of conditions in which it may exist." (See Spencer's 'Principles of Biology,' §§ 91, 156, 169, 170.) In other words, divergence of character in the descendants of one stock occupying different districts does not arise except as it is preceded by difference in the physical conditions, or in the surrounding organisms, of the different districts. After moulding this thought in many forms, Spencer makes it the fundamental principle on which he builds not a small portion of his philosophy. Darwin is more guarded in his statements; still, as we have already shown, he sometimes seems to reason from an assumption quite in accord with what Spencer would have us receive as essential to the very idea of causation in vital processes. For example, his explanation of the fact that on the different islands of the Galapagos Archipelago one genus is, in many cases, represented by several closely allied species which are undoubtedly modified forms of one continental species, seems to rest on the assumption that if every species that gained access to any island had at the same time gained access to the other islands of the archipelago, there would then have been no occasion or opportunity for the divergences we now find (see 'Origin of Species,' 6th ed. p. 355).

It seems to me that the divergences presented by the varieties and species of the subfamily *Achatinellinæ* of the Sandwich Islands are at variance with this assumption. Not only are islands in sight of each other occupied by divergent species, but different parts of the same mountain-range, exposed to the same winds and rains and clothed by the same vegetation, are the homes of divergent forms.

Turning to the map of the island of Oahu, we find a mountain-range extending 36 miles from north-west to south-east nearly parallel with the north-east coast. The north-east side of this range is exposed to the trade-winds fresh from the ocean, and accordingly receives a heavier rainfall than the other side; but there is not much difference in the amount of rain received by the different valleys on one side of the mountain. In nearly all these valleys on either side of the range are found shady groves of what the natives call the "kukui" (*Aleurites triloba*). Many species of the subgenera *Achatinella* and *Bulimella* have their haunts in these groves, some species clinging to the leaves and young branches, and others to the old branches and trunks. Most

of the species thrive only where the shade is dense and the atmosphere laden with dampness a large portion of each month.

The student who starts with the assumption that divergent varieties and species arise only through exposure to different environments, will expect that these groves, at least those on the same side of the mountain-range, will be occupied by the same species. Having found one set of species in a given valley, when he comes to a valley ten miles distant possessing the same conditions of soil, rainfall, vegetation, and shade, where the birds, reptiles, and insects are the same, where the mice and ants, their only known enemies, are the same, he naturally looks on the leaves and branches of the familiar trees for the snails he has found in similar stations not far distant; but what is his surprise to find only different species, all allied to, but quite distinct from, those he has previously known! Twenty miles from the first valley he renews his investigations, finding the forms of all the different groups still more divergent, though all the conditions of the environment are, so far as he can observe, the same.

He finally perceives that he must either assume that there are occult influences in the environment varying with progressive force with each successive mile, or he must give up the theory that the cause of this divergence is exposure to different environments.

3. *When the environment is the same in two districts occupied by allied species or varieties, it is evident that the differences that distinguish the latter cannot be advantageous, even though their differences include strongly contrasted habits.*

For in order that these differences should be advantageous, it is necessary not only that they should relate to the performance of vital functions, and therefore be differences of adaptation, but it is necessary that these differences of adaptation should relate to differences in the environment, so that the forms would be at some disadvantage if they should exchange districts. Adaptational specific differences are not always advantageous, and in such cases the divergence cannot be primarily attributed to diversity in the action of natural selection in the different districts. Under the protection of Isolation, diversity of natural selection may arise which helps in producing divergence; but when the environments are the same, the divergence is in no

sense advantageous, and, in some cases, may even be disadvantageous.

A familiar example will perhaps put the distinction between the causes of existence and transformation and the causes of divergent existence and transformation in a clearer light. The forms of language are growths that are governed by the laws of utility as fully as the forms of varieties and species. Each language and each part of a language exists and persists only as it is found to be of use. The "Survival of the Fittest" is a law that is perhaps as conspicuous in the domain of language as it is in the organic world. Again, every language, like every organic species, is in many respects determined by the environment. A language, for example, developed in Java will present names for many plants and animals that will not be represented in a language developed in Greenland. But, granting all this, does it follow that linguistic differences are necessarily advantageous? The Polynesian system of counting by fours, and the Eskimo system that proceeds by scores, are undoubtedly useful systems; but is there anything advantageous in the difference? I think not, for each system is as well adapted to the environment of the other as to its own environment. We may look upon the more important parts of a language as persisting through their usefulness, the survival of the fittest being the law; but the divergent evolution which brings several languages out of one seems to be principally due to other principles which are closely akin to the principles that produce divergences in the organic world. The fundamental condition in both organic and linguistic divergence is Segregation; and, this being secured, diversity of habits, bringing diversity of aptitudes and diversity in the forms of survival, is sure to arise even when the environment is the same.

4. *Specific differences are not always differences of adaptation to the environment; and those that are not should not be attributed to the action of natural selection.*

It is admitted by every one that a distinction relating to a character that is of no use in the economy of the organism cannot have arisen under the influence of natural selection. Those who maintain that all specific distinctions are due to natural selection maintain at the same time that these distinctions are both adaptational and advantageous. There are naturalists who

maintain that the very essence of the Darwinian theory is "that specific differences must be advantageous," and therefore adaptational; while they do not claim the same for generic, family, and ordinate distinctions, or indeed for varietal distinctions, if I rightly understand *. I have never seen any attempt to explain this supposed exception in the midst of the taxonomic series; and it seems to me that the break in the continuity of nature which this interpretation of the Darwinian theory supposes, should lead us to a very careful investigation of the facts before we accept it as a true interpretation of nature.

I shall content myself with pointing out one distinction, occasionally occurring between allied species, for which no use has ever been, or is likely to be, found. I refer to the distinction between what are known as dextral and sinistral forms. This distinction relates to the tortion of the animal and its shell upon itself. It is most easily recognized by placing the shell on its back with the aperture upward, and observing whether the aperture lies on the right side of the central columella of the shell or on the left. In the first case it is described as dextral, in the second as sinistral. In most families and genera of water-mollusks the sinistral form occurs only as a sport (amongst Mammals the heart is sometimes found on the right side), and even amongst air-breathing mollusks the dextral form vastly predominates. Amongst the *Achatinellinæ*, *Amastra* and *Leptachatina*, which are genera of terrestrial habits, are (with perhaps the exception of one or two species) dextral in form; while the other genera, which are plant-feeders and constantly hanging to branches or leaves, present many species that are constantly sinistral, and many others that are both dextral and sinistral. Why should *Achatinella adusta* in Panoa and Makiki be constantly sinistral, when its nearest allies found in the same valleys are both dextral and sinistral? Why should *Achatinella bacca* and *A. abbreviata* in Palolo and Waialae be constantly dextral when the other species of *Achatinella* in the same valleys are for the most part sinistral? Is there any adaptation to the environment possessed by a dextral form which would be lost if the form was reversed? If not, natural selection could not have anything to do with that part of its character. *Bulimella rosea* is sinistral, while *B. bulimoides* is dextral. If in this respect they should exchange forms, would

* See letter from Mr. W. T. Thiselton Dyer in 'Nature,' vol. xxxix. p. 8.

any disadvantage be experienced by either species? It is impossible to conceive of any disadvantage that would follow, and therefore I cannot believe that this difference in the two species is primarily due to natural, sexual, or any other form of selection.

There are many other specific distinctions presented in this family which seem to be of no advantage, though they are not so far removed from all suggestion of the possibility of use as the character we have just been considering. The brilliant colours and varied patterns presented by many of the arboreal species would be of advantage to themselves, if they served as warning of nauseous qualities to creatures that are liable to prey upon them; but no such creatures exist. The birds of the forest-region are exclusively fruit- and nectar-feeding, and the mice which in recent years have made sad havoc with the mountain snails, unfortunately do not spare the highly-coloured species.

There can be no doubt that when representatives of different groups or subgenera occupy the same trees they remain segregated through the influence of sexual instincts, which must be associated with some means of recognizing those of their own group; but it is not at all probable that the colours and patterns of any species are recognized by their mates, or have been developed under the influence of sexual selection. There is, therefore, strong reason to doubt whether selection of any kind has been concerned in the production of the beautiful colours and patterns of these species, unless possibly correspondences in colour within the limits of a genus are, in some cases, due to the inheritance of tendencies produced by selection when conditions were very different from what we now find. But the divergences in colour and pattern in the species of one genus cannot be thus explained.

5. *The average radius of distribution for species of the same value in different groups of closely-allied species varies in the different groups directly as the power and opportunity for migrating, and inversely as the plasticity and variability of the several groups.*

Comparing the distribution of the *Helices* of Europe with that of the *Achatinellinæ* of Oahu, the most striking contrast is found in the size of the areas occupied. *Helix pomatia* is distributed from England to Turkey, over an area two thousand miles in length, while of the seven genera of *Achatinellinæ* on Oahu

I know of but one species that seems to be distributed over the whole 36 miles of the main mountain-range, and this one is represented by three varieties belonging to different parts of the range and perhaps worthy to be regarded as different species. The species to which I refer is *Auriculella auricula* (Fér.), the typical forms of which are found on the eastern half of the mountain-range. On the other half of the range we find the closely allied forms to which I have given the manuscript names *solida* and *pellucida*. This great contrast in the size of the areas occupied must be due either to the greater plasticity of the Sandwich-Island species, or to their having inferior opportunities for migrating, or to both causes. As I become better acquainted with the great difference in the habits and circumstances of the contrasted species, I give increasing weight to the difference in the opportunities for migrating. With the continental species, floods must be one great means of distribution; but in the case of the insular species, the floods would carry floating individuals upon the grass-land or into the sea, in either case to perish. Again, the habit of travelling upon the ground, which belongs to most of the Helices of Europe and America, gives incalculable opportunities for migration which are not enjoyed by species that are strictly arboreal, as are many of the Sandwich-Island species. Most of the Sandwich-Island species are still further restricted in their opportunities by their inability to resist a dry atmosphere or exposure to the sun, which renders it necessary that they should remain in the isolated areas that are favoured with shade in the different valleys.

The habits of the different subgenera occupying Oahu are also instructive as throwing light upon the relative areas occupied by the species of the different genera. *Achatinella* and *Bulimella* seem to be the most restricted in their opportunities for migrating: first, because they are entirely arboreal in their habits, clinging to the trunks and branches of trees through their whole life-history; and, second, because, for the most part, they occupy the shady and damp thickets and groves, the shade in each valley being separated from similar shades in adjoining valleys by lofty and sparsely wooded mountain-ridges at each side of the valley and by open grass-land at the mouth of the valley. On the other hand, *Apex*, which for the most part occupies trees and shrubs on the ridges which are connected with each other through the central ridge of the mountain-range, and *Amastra* and *Lepta-*

chatina, which are for the most part found on the ground under dead and decaying leaves, seem to possess better opportunities for migration than either *Achatinella* or *Bulimella*. Corresponding with these facts we find the species of *Achatinella* and *Bulimella* especially limited in the areas they occupy, while the species of *Apex*, *Amastra*, and *Leptachatina* are less so. For example, the area occupied by *Amastra turritella*, *A. tristis*, and *A. ventulus* includes the areas occupied by many species of *Achatinella* and *Bulimella*; and *Apex loratus* and *A. pallidus*, occupying the mountain-ridges, range from Makiki to Halawa, exceeding the range attained by any arboreal species occupying the valleys of the same region.

6. *When a group of divergent forms that are fertile with each other are being developed through the influence of local or geographical segregation, other conditions remaining constant, the number of forms that will be produced within a given area will vary inversely as the square of the average radius of distribution for the different forms.*

As this average radius of distribution may be taken as the measure of the power and opportunities for migration, we may say that other powers and opportunities remaining constant, *the number of species developed within a given area will vary inversely as the square of the power and opportunity for migration.*

Though migration is in one sense a cause of isolation, it is evident that the number of isolated groups of individuals does not increase with the increase of migration. Isolation is produced by the great contrast between ordinary and extraordinary combinations of opportunities for migration; and this contrast is as great in the case of species that have limited powers and opportunities, as in the case of those that have very great powers and opportunities. The number of isolations thus produced that can exist within the limits of a given area must vary inversely as the square of the power and opportunity for migration.

The facts of distribution we have been considering seem to correspond to this law.

7. *Forms that are most nearly related, and are therefore the least subject to sexual and impregnational segregation, are distributed in such a manner that their divergence is directly proportional to their distance from each other, which is also the measure of the time and degree of their geographical*

segregation; while those that are most manifestly held apart by sexual instincts and impregnational incompatabilities do not follow this law.

Bulimella is represented by two groups of species, one of ovate form, the other elongated and with the outlines of the spire less rounded. The widest divergence between these groups is presented by species occupying the same districts and valleys, but the widest divergences in the species of either of these groups are found in valleys widely separated. In the latter case, the degree of geographical separation is probably an approximate measure of the time and degree of segregation, and therefore the measure of the degree of divergence; while, in the former case, the segregation is probably as complete between forms occupying the same valley as between those of widely separated valleys. There is reason to believe that in the eastern part of the island these two groups are not held apart by sexual segregation or segregate fecundity and vigour, for there is complete intergrading, and the divergence between the groups in any one valley is much less than is found in the north-west portion of the island, where sexual incompatibility seems to hold them apart.

Achatinella bacca and *A. abbreviata* completely intergrade with each other, but they are associated with a number of other species of *Achatinella* with which they do not intergrade, prevented it seems to me by mutual antipathy and sterility. We have, therefore, in the eastern valleys two groups of *Achatinella* completely segregated from each other, though occupying the same districts and in some measure the same stations; while in the other valleys the two groups coalesce, the different species occupying any one valley being only partially segregated by divergent habits of feeding

The different subgenera, which are undoubtedly segregated by divergent sexual instincts, as well as by physiological incompatibilities, are equally divergent, whether we compare forms from the same, or from distant valleys.

8. *The distribution of the varieties, species, and genera of* Achatinella *on this island is just such as would be produced by divergent evolution, which depends on segregation as a necessary condition even when the environments are different, and which always follows long-continued segregation even when the environment surrounding the different sections is the same.*

Increasing difference in the forms of natural selection does not necessarily depend on exposure to different environments, but does depend on some form of Independent Generation. It may be safely said of the multitude of varieties which inhabit the island of Oahu, that every one is more or less segregated from all other varieties. And I believe this will be found true concerning varieties in every part of the world. This fundamental fact would probably never have been denied, except for the delusive idea that the advantage of divergence would lead to the accumulation of divergence even if segregation were entirely wanting. What could be a greater mistake for the breeder of animals than to imagine that by selecting extreme variations and breeding them together he would in time secure well-marked races? It must be equally at variance with fact to suppose that any advantage secured by divergent variations can be preserved and accumulated while the different forms are freely intergenerating.

In the family we are considering, the chief forms of segregation are probably what I have called local, geographical, industrial, and sexual segregation, strengthened in many cases by segregate fecundity and vigour. As illustrating local segregation I would mention varieties and species of *Apex*, for the most part occupying the mountain-ridges which are all connected with each other, without the intervention of geographical barriers. Geographical segregation is illustrated in the forms of *Achatinella* and *Bulimella*, which for the most part occupy the deep valleys, the ridges forming barriers that are very rarely surmounted. Industrial segregation is illustrated by the closely-allied varieties of one group of species that occupy one valley, but are prevented from freely crossing by different habits of feeding. It is probable that sexual or seasonal segregation prevents the pairing of *Achatinella* with *Bulimella* when both occupy the same trees. Moreover, cross sterility would undoubtedly prevent the multiplication of the hybrids, if cross-unions ever do occur between forms so widely divergent. There can be no doubt that the same principles prevent the strongly marked groups of either genus from intergenerating; as for example, in the case of *Achatinella bacca* and *A. abbreviata*, which are intergraded with each other, but not with the surrounding species of *Achatinella*.

Again, divergent forms of natural selection do not necessarily depend on exposure to different environments. Industrial Segregation is produced by different methods of using the environ-

ments; and the same cause will often produce diversity in the forms of natural selection affecting the segregated sections. Cumulative divergence in the methods of using the environment in the different branches of the species depends upon their segregation, and, therefore, increasing divergence in the forms of natural selection affecting the different branches depends on their segregation. But Industrial Segregation is not the only form of Independent Generation that opens the way for increasing diversity of natural selection. Geographical Segregation under the same environment, though it does not of itself produce divergent forms of selection, opens the way for change in the habits of feeding with diversity of natural selection in the different sections of the species. Take, for example, the species of *Achatinella*: in Manoa and Mikiki they chiefly occupy the Kukui (*Aleurites triloba*) and other trees, while in Kawailoa and that region they neglect the larger trees and take to the Lobelia and other shrubs and herbaceous plants.

But why should the degree of divergence increase with the continuance of the Segregation? The answer seems to be that the combined effects of the different principles of transformation in the segregated groups increase with the time of segregation; and, as independent transformation is never parallel, the divergence increases in the same ratio. Diversity of natural selection is undoubtedly one of the principles producing this divergence, even when the vegetation and physical conditions of the different districts are the same, for when the habits of feeding change, the natural selection must usually change. But there are cases of divergence accompanying Segregation in which the habits of feeding seem to have remained unchanged; and in such cases I explain the divergence in part by the principle that separation always involves more or less segregation, and in part by the influence of the four principles which I have called Assimilational, Eliminational, Amalgamational, and Fecundal Transformation. Of these, Eliminational and Amalgamational Transformation are perhaps the most constantly operative. The principle of unbalanced Elimination is closely allied to the principle that separation involves Segregation; for both represent phases of the fact that any small fragment of a species is incapable of propagating all the qualities of the species in the exact proportion presented by the average of the species.

Similar Facts in other Fields.

Many of the facts embodied in these eight propositions must have been observed wherever naturalists have studied the geographical distribution of the varieties and species of polymorphic genera; but in the distribution of the *Achatinellinæ* there are features of peculiar interest arising from the fact that the powers of migration possessed by the species of the surrounding environment are very much greater than those possessed by the *Achatinellæ*. Through this circumstance a comparatively uniform environment is produced in which the effects of Independent Generation unmodified by the effects of changed environment may be observed. The remarkable facts of distribution which we have on the island of Oahu are found in other parts of the Sandwich Islands, wherever this family occurs. I am also fully convinced that, in other parts of the world, wherever one genus or family of very low powers of migration is surrounded by a body of plant and animal forms possessing much higher powers of migration, these similar facts will present themselves whenever investigation is made.

The distribution of land-mollusks belonging to the genus *Partula* found on the Society Islands presents similar features. The island of Reiatea, which is but 14 miles in length and 3 or 4 miles in breadth, is the home of about 30 species and varieties, most of which are confined to areas only a few square miles in extent. I am not informed as to the distribution of the vegetation on which these species feed, but there is no reason to suppose they occupy limited districts corresponding to those occupied by the different species of *Partula*.

Divergence in Insects.

The dependence of divergence on some form of Segregation is most clearly exemplified in insects, and though my studies are but limited in that field, I shall refer to a few cases, which may serve to direct attention to a class of facts of the highest interest not only to Entomology but to general Biology.

Divergence in the Species of the Lepidopterous Genera *Erynnis* (*Pamphila*) and *Thanaos* (*Nisoniades*).

These two genera of small North-American butterflies are worthy of the special attention of those who are studying the

problems of divergent evolution; for they furnish strong indications that organisms which are with difficulty distinguished from each other by external form or colour, may, nevertheless, be well established species—segregated presumably by sexual instincts corresponding to sexual characters by which those of opposite sexes of the same species readily recognize each other, and probably cut off from the possibility of producing hybrids through incompatibility of physiological endowments. In the origin of some of these species Geographical Segregation may have had an important influence; but concerning others there can hardly be a doubt that the segregative influences, holding apart species that occupy the same districts, were, from the first, peculiarities of their sexual instincts and constitution. The reason for accepting this view of their origin is found in the fact that, though slightly divergent in other points, the characters by which they are clearly distinguished are found in the forms of the male genitalia; and in the characters of these organs we find clearly marked species, for the most part free from the intergrading forms which would certainly be presented if the different species were not prevented from crossing by sexual instincts or constitution.

A full description of these genera, with observations on the asymmetrical development of the right and left sides of the genital armature in *Thanaos*, will be found in Scudder's 'Butterflies of New England;' see also Mem. of the Boston Soc. Nat. Hist. ii. (1874), and Proceedings of the same Society for April 27, 1870, vol. xiii. p. 282 (1871).

Divergent Species of *Basilarchia*.

Basilarchia (Scudder) is an attractive genus of butterflies peculiar to North America, where it is represented by four or five species. Three of these are found in New England, and are minutely described in Scudder's 'Butterflies of New England,' from which I draw my information (pp. 250–305).

The distribution of these three species is of great interest, as it illustrates divergence both with and without Local Segregation. *B. Archippus* ranges over nearly the whole of the United States and over the southern portion of Canada. *B. Astyanax* occupies the valley of the Mississippi and eastward to the Atlantic from the Gulf of Mexico on the south to the lakes on the north. *B. Arthemis* is distributed from Newfoundland

and Nova Scotia on the east, over New England, Canada, the region of the lakes, away to the north-west, toward the confines of Alaska. It will be observed that the area of distribution of *B. Archippus* includes the whole of that of *B. Astyanax* and a large portion of that of *B. Arthemis*; while the areas of *B. Astyanax* and *B. Arthemis* overlap along the whole northern border of the territory occupied by *B. Astyanax*. This area of overlapping distribution in which the three species are associated is about a thousand miles in length, and from one hundred to one hundred and fifty miles in width.

Forms of Segregation that separate B. Archippus *from* B. Astyanax *and* B. Arthemis.

It is evident that, in the present condition of distribution, geographical barriers and territorial separation have nothing to do with the integrity of *B. Archippus* as a separate species. In other words, it is not under the influence of Geographical or Local Segregation. Whatever may have been its past history, these certainly are not the causes that at present prevent it from interfusing with other species of *Basilarchia* with which it is associated.

Again, Seasonal Segregation seems to have but little influence; for, though *B. Archippus* seems to appear 15 or 20 days earlier than the other species, the remainder of the breeding-season, which extends over many weeks, is coincident.

The habits and feeding instincts of this species must tend to separate it somewhat from *B. Arthemis*, for this latter species frequents forest-regions, especially when elevated and hilly, while *B. Archippus* is found in the open country in fields and meadows, especially in low levels. The eggs of *B. Arthemis* are chiefly deposited on the species of birch and willow that are found on the highlands; while the eggs of *B. Archippus* are chiefly deposited on the willows and poplars found on the lowlands, though on the White Mountains it occasionally extends its range to as high levels as *B. Arthemis*. There is therefore between these species a slight degree of Industrial Segregation; but this partial segregation does not prevent their being often found in the same fields, and unless held apart by sexual instincts and by partial infertility, hybrids, which are now very rare, would be very common.

We are therefore lead to believe that diversity of sexual

instincts, accompanied by a considerable degree of cross-sterility, is the chief cause preserving the independent character of this species. Except for the sexual Segregation and Segregate Fecundity there is every reason to believe that this species could never have arisen, or, if it had arisen as a variety in some isolated locality, would have been submerged in the allied forms when its wider distribution was reached. This conclusion, which has been reached by observing the general relations of the species, is confirmed by a minute examination of the structure of the three species. We find that while the male genitalia of *B. Astyanax* and *B. Arthemis* differ but slightly, those of *B. Archippus* are considerably divergent. This is an index of the psychological and physiological relations of varieties and species of no small importance; for a comparison of many species shows that differences of this kind are usually accompanied by corresponding degrees of segregation in sexual instincts and of cross-sterility. In other words, we find that difference in the male genitalia, which is a form of segregate structure, is an index of Sexual Segregation and Segregate Fecundity.

The partial Segregation of B. Astyanax *and* B. Arthemis.

In the relations of these two species we find examples of segregative influences differing somewhat from those that have just been found in the case of *B. Archippus.* Regional Segregation, with exposure to different climates and adaptations to different food-plants, has undoubtedly had an important influence in the formation of these species; but, in the part of the country where they co-exist, their life-histories correspond completely, and cross-unions seem to be frequent. The hybrid form has been described as a separate species, and some entomologists have classed it as a dimorphic form of *B. Arthemis*, but Scudder gives several reasons for believing that it is the result of cross-unions between these two species. There are, however, several reasons for believing that partial Segregate Fecundity exists between the two species; for, in the strip of territory where the two are associated they do not completely coalesce, as would be the case if they were completely cross-fertile. In Scudder's 'Butterflies of New England,' pp. 159–160, we find mention of two species (*Cercyonis Alope* and *C. Nephele*), in which the cross-sterility must be considerably weaker than between the two species we are now considering; for, in the intermediate region

in which their areas overlap, the intergrade forms are comparatively abundant. Moreover, the difference in the male genitalia of *B. Astyanax* and *B. Arthemis*, though much less than that which appears when either of these is compared with *B. Archippus*, is such as indicates a considerable degree of infertility.

In these two species we have then a good example of partial Segregation through distribution over areas, which, though overlapping, are for the most part distinct, reinforced by partial Segregate Fecundity which may or may not be accompanied by slightly divergent sexual instincts. There is also some Segregation resulting from the fact that the plants on which *B. Arthemis* seeks to deposit its eggs are chiefly the birches and willows of the hilly country, while *B. Astyanax* prefers fruit-trees of the Rosaceæ family, and other plants that are found in the more open country. These are, as I have shown in my paper on "Divergent Evolution through Cumulative Segregation," exactly the conditions that produce, in successive generations, increasing degrees of Segregate Fecundity.

Cumulative Segregation in the Formation of the above Species.

I judge that in the relations to each other of these three species we have the results of divergent evolution through cumulative segregation very clearly illustrated. In the earlier stages of divergence in this genus, *Basilarchia Archippus* with its fondness for the open fields must have become partially separated from the parent form from which both *B. Astyanax* and *B. Arthemis* have since sprung. The separation may have been in some measure due to what I have called Protectional Segregation; for we find that the form that has kept to the open country has through protective selection gained a very close resemblance to the colouring of *Anosia plexippus*, which is protected by its disagreeable qualities. The other form has probably gained compensative advantages by keeping closer to the woodlands. But the partial Segregation thus produced would never have resulted in constant specific differences if Segregate Fecundity had not arisen between the two forms. We may believe that some form of Impregnational Segregation (either Segregate Structure, Segregate Fecundity, or Segregate Vigour) was early introduced, and that under the protection of this barrier the specific distinctions of the two forms became fully established, though even now the barrier is not so complete as to

entirely preclude hybrids between *B. Archippus* and each of the other species. Examples of both these hybrids are described by Scudder.

While this Segregation was being completed, one of the two forms thus created must have become subject to a new set of segregative influences, arising from wider distribution with diversity of climate and of habits of feeding, reinforced by a slight degree of Segregate Fecundity. *B. Astyanax* and *B. Arthemis* are the two species resulting from this last Segregation, and the process is so far from being complete, that wherever the areas of these two species overlap a hybrid form, which has been known as *B. Proserpina*, appears. That it is a hybrid is proved by the fact that it "varies most toward *Astyanax* where this prevails, and most towards *Arthemis* where that prevails," that it is found only in the narrow belt where the two species are brought into contact, and that it has been reported from so many points in this narrow belt that there is reason to believe that it occurs wherever the two species are brought into contact. If our exposition of the Segregations to which these species have been subjected is correct, they are cumulative in two respects—first because after one Segregation has been established another is superimposed, and second because a partial segregation established in one generation tends to become more complete in subsequent generations.

The primary causes in the whole process are the activities of the organisms acting upon each other and upon the environments in such a way as to produce, in the first place, Independent Generation with some degree of divergence, and then Unbalanced Natural Selection and other forms and transformation, which, acting upon selections of the species that are prevented from crossing, result in ever increasing divergence.

Divergent Evolution in the Periodical Cicada (*Cicada septemdecim*) *.

In this species we have examples of two quite distinct divergences, each depending on its own forms of Segregation, which are easily recognized.

The life-history of this insect covers 17 years and one or two

* My information is chiefly derived from the U.S. Department of Agriculture (Division of Entomology), Bulletin No. 8, by Dr. C. V. Riley.

months. The imago appears late in May, and for a little more than a month the males make the woods ring with their shrill stridulations. The eggs, which are deposited in the green twigs of trees, mature during the latter part of July; and each newly-hatched larva dropping to the ground, takes up a solitary subterranean life, which it follows till its period of 17 years is nearly complete. It then appears above the ground, passes into its winged stage, and enters on a few weeks of social life which closes its career. This species is widely distributed in that part of the United States that lies between the Atlantic shore and the Rocky Mountains. It does not, however, occur in Minnesota; Northern Michigan, or Northern New England. It is, however, represented by two races in every respect the same, except that one has a life-history of thirteen and the other of seventeen years. The 13-year race prevails in the Gulf States, while in New England and the Middle States the 17-year race is alone found. In Illinois, Missouri, Kansas, and in several of the Southern States the two races occur in the same localities; but it is evident that even in such localities it is only once in 221 years that there will be any opportunity for crossing between them, and we are informed by those who have made a special study of the subject that they do not cross when these opportunities occur.

These two races are therefore protected by partial Local Segregation; by Cyclical Segregation rendering it impossible that a brood of each occupying the same locality should have opportunity for crossing more than once in 17 generations of the shorter-lived race, or once in 13 generations of the longer-lived race; and by Sexual Segregation that shows itself in diversity of instincts preventing them from pairing when other conditions favour.

Whether devices have been tried to induce cross-unions, and whether such unions are unfruitful, I have never heard; but the simple fact that 15-year forms do not appear in localities where the two races are found, indicates that in nature they do not cross. Several such localities have been reported, but in none of them has an intermediate form been found. It seems, therefore, that we may safely draw the conclusion that we have here a case of complete Sexual Segregation between forms which to the human eye are undistinguishable, and which call their mates with stridulations which to the human ear are the same. Now I claim that in such races as these we have the beginning of divergent species—a beginning that lies in the segregative influences of constitutional

and instinctive qualities persistently inherited by the two races, though the naturalist who examines specimens of the two races cannot distinguish them. All that is necessary to convert these two races into good species is the transformation of one or both of them while they are thus prevented from crossing; for we may be assured that the results of transformation under such circumstances will never be completely parallel.

Each of these races is again subdivided; for accompanying each is a diminutive form, differing somewhat in colour, not so early by eight or ten days in its first appearance, producing a quite distinct stridulation, and showing no disposition to associate with the larger form. This small form was described in 1851 by Dr. Fisher as a new species under the name *Cicada Cassinii*. Dr. Riley, however, hesitates to receive it as a separate species because the differences presented by the male genitalia are not constant. He says "there are sufficient differences to separate the two forms as distinct; but while the hooks of the large kind (*septemdecim*) are quite constant in their appearances, those of the smaller kind (*Cassinii*) are variable, and in some few specimens are indistinguishable from those of the large kind. This circumstance, coupled with the fact that the small kind regularly occurs with both the 17- and 13-year broods, would indicate it to be a dimorphic form of the larger, and only entitled to varietal rank"*.

I consider this case as of equal interest with the previous one; for it is an example of complete segregation between the forms of one species through diversity in their instincts. Whether these divergent instincts are sexual or social may be a matter of question; but in either case they are effectual in preventing crossing.

If future investigation shows that the small form is often produced directly from the eggs of the large form, it will have but little claim to be regarded as a separate race; but even then, if the small form breeds only with its own kind, as has been reported by several observers, and if the offspring persistently reproduce the characters of the parents, it will have to be considered something more than a dimorphic form of the large one. It would, in that case, be a dimorphic form that is assuming the

* United-States Department of Agriculture (Division of Entomology), Bulletin No. 8, p. 7.

character of a species. If the two forms were without segregative sexual and social instincts, then, with cross-fertility, the small form would be rapidly absorbed by the large form, which greatly preponderates in numbers; and with cross-sterility the small form would rapidly become extinct; for, through the comparative scarcity of their numbers; the representatives of the small form would have but little chance of mating with each other.

On the other hand, if the Sexual and Social Segregation is complete, it matters but little whether the forms are mutually sterile, for the separate races or species will be protected by the Positive Segregation produced by the divergent instincts, even if the Negative Segregation, depending on structural incompatibility and lack of physiological adaptation, is entirely wanting. It is only when associated with Positive Segregation that is partial in its results, that Negative forms of Segregation become important factors in the preservation of diverging forms.

In animals that pair, Segregation through sexual and social instincts plays a similar rôle in giving pre-emptive power to the males of a given species over the females of the same species, that is played by Potential and Prepotential Segregation in organisms whose fertilizing elements are distributed by wind or water. In the one case Instinctive, and in the other Potential Segregation, arising between varieties of the same species, marks these varieties as being the initial forms of divergent species.

This species presents another form of Segregation which is of much interest, though it has not yet resulted in forms that can be ranked as different races. I refer to the complete Cyclical Segregation that exists between the different broods of a given race appearing in different years. Of the 13-year race there are seven broods, and of the 17-year race fourteen. As an example of different broods occurring in the same region I would mention the two broods in the district of Columbia, one appearing in 1885 and at intervals of seventeen years thereafter, and another appearing in 1894 and at intervals of seventeen years thereafter. We have no means of testing the sexual or social instincts of these different broods, for they never appear in the same year. No one can say whether if they could be brought together they would be found as indisposed to breed with each other as are the 13-year and 17-year races. But, be that as it may, the two forms are as completely segregated as they can be, and the opportunity for independent, and therefore divergent, transformation is much

the same as that which exists between the 13- and 17-year races. Two or three of the States have but one brood each; but in Ohio seven 17-year broods are reported, and in North Carolina one 13-year and six 17-year broods. I judge, however, from the reports that, even in these last-mentioned States, there are but few places, if any, where more than three broods overlap.

I have not seen any discussion of the causes that have produced these broods, but if we may believe that they have existed for a thousand generations, a possible if not probable cause is found in the unsettled conditions of climate that must have attended the breaking-up of the great ice-period. During years of diminished cold, colonies may have taken possession of regions which were too cold for their development at the return of the 17-year period when the offspring should have appeared; and still some of the benumbed and delayed pupæ may have survived, making their appearance one, two, three or more years later, when conditions were more favourable. The following observation referred to by Dr. Riley, in explanation of the accelerated or retarded appearance of sporadic individuals, throws some light on the origin of the different broods:—"That circumstances favourable or otherwise may accelerate or retard their development was accidentally proven in 1868 by Dr. E. S. Hull, of Alton, Ill., as by constructing underground flues for the purpose of forcing vegetables, he also caused the Cicadas to issue as early as the 20th of March, and at consecutive periods afterwards till May, though, strange to say, these premature individuals did not sing. They frequently appear in small numbers, and more rarely in large numbers, the year before or the year after their proper period. This is more especially the case with the 13-year broods"*. That climate has been an important factor in the development of the 13- and 17-year races is indicated by the fact that most of the districts occupied by the 17-year race lie north of lat. 38°, and most of those occupied by the 13-year race lie south of that line, though in Illinois there is a 13-year brood as far north as lat. 40°. Dr. Riley has not referred to the coincidence, but it seems to me a fact of some interest in this connection, that the southern limit of the great ice-cap which covered Canada and the northern part of the United States during the Glacial epoch extended along

* U.S. Department of Agriculture (Division of Entomology), Bulletin No. 8, p. 8, by C. V. Riley.

an irregular line between the parallels of lat. 38° and 40°. Lying south of the ice-region there was probably a considerable belt of country covered with pines and other conifers not adapted to the breeding of this species, so that both races, if they then existed, must have been crowded into the southern portion of the region now occupied by the 13-year race.

Instinctive and Cyclical forms of Segregation, such as cause the independent generation of the races and broods of this species, are usually associated with clearly developed specific distinctions relating to form, colour, and function. This does not, however, prove that the segregative divergence was subsequent to the general divergence in other respects; for if complete segregation continues for many generations it is likely to be followed by other divergences, and the divergent forms are then ranked as separate species. Moreover, the number of generations covered by the initial stage in which the different sections are only races is very small compared with those that are likely to be covered by the stages when they are separate species and genera. It is only, therefore, by rare chance that we find two forms that are still in the earliest stage of divergence and are, at the same time, completely segregated by constitutional differences. Again, segregative endowments are usually developed somewhat gradually; and while the segregation is advancing other transformations take place, so that by the time all crossing has come to an end the different sections have become well-marked species. Sometimes, as in the case of the three species of Butterflies already considered, there is more or less crossing after the sections have become quite distinct species. Such cases, however, as are presented by the 13- and 17-year races and by the different broods of this species of *Cicada*, show that complete segregation may be produced by the psychological and physiological constitution of different races, while distinctions of form, colour, and manner of call are entirely wanting so far as we can observe. This has seemed impossible to some naturalists, especially since Darwin has admitted that cross-sterility cannot be attributed to natural selection, and has therefore attributed it to the indirect effects of other qualities which have been produced by natural selection.

The great contrast in this respect between the species of *Basilarchia* and the 13- and 17-year races of *Cicada septemdecim* may perhaps be partially explained by the fact that the latter spend the greater part of their existence under ground, where the con-

ditions have not been seriously changed since the close of the last glacial period. Again, one generation of the 17-year race of *Cicada* covers a period equal to that of thirty or forty generations of the *Basilarchia*, bringing thirty or forty fluctuations of climate, food, &c. to the latter, while the former is, for the most part, protected from serious fluctuations.

It is of course equally impossible to prove by all-inclusive observations, either that transformation is never completely parallel in sections of a species that are prevented from crossing, or that independent generation long continued is sure to result in independent transformation, and therefore in divergence; but it is of no small interest that we find in the 13-year and 17-year races of this species the strongest proof that there are sometimes divergences which our senses do not perceive. If our senses were a sufficient test, it might be maintained that between these races a high degree of local and Cyclical Segregation has existed for many generations, without any other form of transformation having arisen to increase the divergence; but if our informants are correct when they tell us that these races do not cross when appearing in the same district and at the same time, we need not hesitate to affirm that there must be some distinguishing characteristics by which those of one race are able to find each other, as well as segregative instincts which lead them to choose each other's society; and, even if our informants are mistaken in supposing that cross-unions do not occur, there must be some form of incompatibility between the two races, resting on divergent endowments; for otherwise we should find hybrid descendants with periods of more than 13 and less than 17 years' duration.

Concluding Remarks.

Outline of the Argument in support of the Theory of Divergent Evolution through Cumulative Segregation.

(1) The invariable experience of mankind in producing domestic races shows that Segregation is a controlling factor. The Segregation that produces domestic breeds and races is found to be of two kinds: first, that which is produced by men who designedly preserve the different styles of variation presented by one species, while at the same time they prevent them from crossing; and, second, that which commences in the indiscri-

minate division of the species into sections that are prevented from freely crossing through their being under the care of separate tribes of men, and which is changed into decided Segregation through the diversity of selection, or of some other transforming principle, to which the different sections are sure to be exposed; for it is found that these principles when brought to bear on separated sections never produce completely parallel effects.

(2) The paramount effects of Independent Generation having been shown in the broad fields of biological experiment presented by the domestication of plants and animals, the question is next raised whether species in a state of nature are subjected to influences dividing the individuals of one species into sections that are prevented from crossing; and if they are, how far this Independent Generation involves Segregate Generation.

In my paper entitled "Divergent Evolution through Cumulative Segregation" it was shown that there are many classes of activities by which the individuals of a species are thus divided, and that, in the majority of cases, the very process that separates them assorts them into classes with reference to one or more points of character; thus producing segregation that is completely parallel in its character to the segregation that is designedly produced by the pigeon-fancier between his various breeds of pigeons.

In the earlier half of the present paper I have shown that the indiscriminate division of the species, which often results from migration or geological changes, and sometimes from other causes, inevitably involves some Segregation; and whenever the transforming influences of the other factors of evolution begin to operate in the different sections, this initial Segregation is inevitably intensified and the divergence increased; for it is in the last degree improbable that change produced by these principles of transformation in sections that are prevented from crossing should be completely parallel in the different sections, even when exposed to the same environments. Having shown that the forms of Segregation produced in nature are analogous to those produced in artificial breeding,—

(3) The last step is to show, as has been attempted in the latter half of the present paper, that the relations to each other of varieties, species, genera, and the higher groups are such as would necessarily be presented if all such differences were the result of evolution that is always dependent on some form of

Segregation, but not always on diversity of natural selection, nor always on exposure to different environments.

We have found that persistent differences, whether varietal, specific, or generic, are not all adaptational, for some of them have no relation to utility ; and that adaptational differences are not all advantageous, for some of them relate to adaptations that would meet with equal success if the organisms should exchange habitats ; but that in every case divergence, whether utilitarian or non-utilitarian, whether advantageous or disadvantageous, is not maintained without Independent Generation.

Reply to Criticism.

In view of the examples of divergence that have been discussed in this paper, I think I may state, as in my previous paper, "It is therefore evident that the simple fact of divergence in any case is not sufficient ground for assuming that the divergent form has an advantage over the type from which it diverges" *. Mr. Wallace has criticised this statement, using the following words †:—"It seems to me that throughout his paper Mr. Gulick omits the consideration of the inevitable agency of natural selection, arising from the fact of only a very small proportion of the offspring produced each year possibly surviving. . . . . He omits from all consideration the fact that at each step of the divergence there was necessarily selection of the fit and less fit to survive ; and that if, as a fact, the two extremes have survived, and not the intermediate steps that led to one or both of them, it is a proof that *both* had an advantage over the original less specialized form." But what if the type from which the new form diverges is surviving at the same time that the new form survives? And what if both the forms are surrounded by the same environment which they use in different ways? Where then is the proof that the newer form has an advantage over the older form? This was the class of facts I had been considering in the preceding paragraphs, which led to the conclusion criticised by Mr. Wallace; and instead of omitting "the consideration of the inevitable agency of natural selection," it was the very thing I was considering, as will be seen by referring to p. 213. I had pointed out, that when a segregated portion of a species exposed to the

* Linnean Society's Journal, Zoology, vol. xx. p. 214.

† Nature, vol. xxxviii. p. 491.

same environment changes its habits, learning to appropriate resources that had not been previously used, it becomes a new intergenerating group "*in which a new and divergent form of natural selection is established*;" but that the result of the divergence thus produced is not necessarily advantageous, and may for many generations be somewhat disadvantageous. As I was aware that many naturalists would consider it absurd to suppose that disadvantageous, or even non-advantageous instincts, ever persist and become the occasion of divergent selection, I referred to Darwin's opinion that such might be the case with sexual instincts, and that the progenitors of man were deprived of their hairy coat by sexual selection that was, in its earlier stages, disadvantageous. I am not aware that Darwin has ever attempted to show how divergent sexual instincts arise and become permanently fixed as distinguishing characters of varieties and species. "The Advantage of Divergence," the principle on which he relied to account for divergent habits, producing divergent natural selection, he never attempted to apply here; and, above all, when he believed the newer instinct to be either non-advantageous or disadvantageous, as contrasted with the older instinct, he certainly could not have attributed advantage to the resulting divergence. As I have pointed out on previous occasions, Darwin assumed a psychological divergence in the sexual instincts of a species in order to account for the divergence in their secondary sexual characters relating to form, colour, &c.; and as there is no reason given why the psychological divergence should take place, or why it should precede the change in form and colour, the theory of Sexual Selection, as presented by Darwin, is incomplete and unsatisfactory, especially in its relations to divergent evolution. If he had thrown light on the causes of divergence in sexual instincts, he would have found the same or similar principles applicable to the explanation of divergence of all kinds. But my object in referring to his opinion here is to point out that he was free to admit that permanent divergence in sexual instincts may be non-advantageous, or even somewhat disadvantageous; and if this is true of sexual instincts, I do not see why it may not be equally true of industrial instincts. I think there is ample evidence that, when segregation has been established, divergence which is neither advantageous nor disadvantageous often arises in industrial as well as other instincts, and that these instincts may introduce new forms of natural,

sexual, or social selection. The relations which exist between habits and their objects are in many species constantly varying in such a way as to constitute a series of experiments; and when independent generation exists between different sections of a species, there is nothing to prevent divergence in the results of those experiments in the different sections, even when exposed to the same environment.

In Darwin's 'Posthumous Essay on Instinct,' published as an Appendix to Romanes's 'Mental Evolution in Animals,' on pages 378–384 mention is made of certain "imperfections and mistakes of instinct," and of certain instincts "that are carried to an injurious excess," and of others that are "small and trifling." Of the last-named he says:—"I have not rarely felt that small and trifling instincts were a greater difficulty in our theory than those which have so justly excited the wonder of mankind; for an instinct, if really of no considerable importance in the struggle for life, could not be modified or formed through natural selection." After mentioning several which might perhaps be considered trifling but are really of great importance to the species, he alludes to a few that seem to be "mere tricks" or "habits without use to the animals." Mr. Romanes, referring to these cases, offers the following explanation on p. 275 of the same work (I quote from the New York edition, Appleton & Co., 1884):—"We have seen abundant evidence that non-adaptive habits occur in individuals, and may be inherited in the race. Therefore, if from play, affection, curiosity, or even mere caprice, the animal should perform any useless kind of action habitually...., and if this habit were to become hereditary in the similarly constituted progeny, we should have a trivial or useless instinct." As an example of a strongly inherited non-adaptive instinct in a wild creature may be mentioned the cackling of the wild hen of India after having laid an egg. This habit is referred to by Darwin as one that may be slightly detrimental; but all that is necessary to put it beyond the developing influence of natural selection is that it should fail of bringing advantage to the species; and that it is of no advantage will, I think, be generally admitted. If, then, species differ in regard to instincts that are non-advantageous, they are liable to present non-advantageous differences in form and colour, resulting either from the same causes that have produced the divergent instincts, or from divergent forms of natural, sexual, and social selection produced by

these instincts; it will, however, be found that Segregation is the cause, or at least the necessary condition, on which the divergence depends.

In the present paper I have mentioned cases, representative of multitudes of others, in which there is divergence between two varieties or species occupying different districts, but surrounded by the same environments. In such cases, the differences presented by the separate forms and the divergence by which the differences have been produced, cannot be regarded as advantageous; for if the forms should exchange districts, the environment being the same, no disadvantage would be experienced; and this is equally true whether the differences relate to industrial adaptations, or to adaptations between the sexual instincts and the other secondary sexual characters of the group, or to characters that are absolutely non-utilitarian.

Mr. Wallace says that, in my previous paper, he looks in vain for any proof that cumulative segregation produces cumulative divergence; but at the same time, he claims that the segregation of which I speak, and which I have illustrated by a supposed case in the breeding of pigeons, is a form of selection which he calls "selection by separation." Adopting his phrase for the moment, I understand that he fully admits that in domestication "selection by separation" will produce divergence. Does he then doubt that the same process produced by natural causes will result in divergence? Or does he deny that "selection by separation" ever takes place in nature? He will probably grant that wherever natural causes act upon the representatives of a species in such a way that in each generation those presenting one style of variation are led to breed together and are prevented from breeding with other kinds, there divergence will certainly follow. This is what I call Segregation. That without it there is no cumulative divergence, and that with it there is always divergence, is amply proved by the universal experience of man in the domestication of plants and animals. All that is lacking is the consistent application of our knowledge to the theory of evolution.

Segregation is a process of much deeper significance than indiscriminate isolation, with which he seems to confound it; and one which in nature arises from a wide range of causes, some of which I have pointed out. But isolation without assortment of the forms according to any principle by which those of a kind are brought together, is often transformed into Segregation by

the operation of the principles of transformation in the isolated sections of the species. This change is often brought about by the difference of the environments to which the organism is exposed in the isolated areas. This one form of Segregation has been clearly pointed out by Darwin, though he did not recognize segregation as a necessary condition for divergence. There are, however, many other ways in which nature produces a similar result. Some of these are operative when the organism is distributed in isolated districts but surrounded by the same environment, and some of them have to do with the development of non-adaptative divergences, which cannot come under the cumulative influence of natural selection.

It thus appears that Independent Generation co-operating with Natural Selection is one form of the wider principle of Segregation, which, in its many forms, is the ever present condition preceding cumulative divergence. Whatever divides the representatives of a species in such a way that those of a kind are made to intergenerate while prevented from intergenerating with other kinds is a cause of Segregation. This is my definition of Segregation; and my theory is that whatever causes Segregation causes divergence, and without Segregation there is no cumulative divergence. Now, in order to refute the theory it is necessary to show either that Segregation does not take place in nature, or that it is not accompanied by divergence, or that divergence takes place without Segregation. As Mr. Wallace has not attempted to prove any one of these counter propositions, I think his criticism is aside from the main issue. Even if my paper presents "a body of theoretical statements" with "no additional facts," this does not show that the theory is incorrect or the new use of the old facts unimportant in the explanation of divergent evolution. 'The Origin of Species' was filled with new theories applied to old facts. The importance of Cumulative Divergence through Cumulative Segregation, if a fact, is admitted. Is it a fact? is then the question that needs to be discussed; but, if Segregation is supposed to be no more than Isolation, the discussion will be of little avail.

In the Journal of the Royal Microscopical Society, 1889, part i. pages 33–4, will be found an appreciative, though a very brief review of my theory, closing with the suggestion that fuller elucidation is needed of the alleged tendency in nature to transform separation, when long continued, into increasing segregation

and divergence. Want of space in my first essay made it necessary to postpone the full discussion of this part of the theory; but in the present paper I have sought to point out some of the more manifest principles on which this general law of *Intension* rests. There are undoubtedly other principles of transformation, which, when combined with separate breeding, inevitably produce divergent instead of parallel evolution; but the principles pointed out in this paper are sufficient to establish the general tendency, and to show that natural selection is by no means the only principle on which the law rests. If we could obtain sections of a species presenting exactly the same average character, and if we could prevent all the principles of transformation from coming in to aid in the process, separate breeding under such conditions would perhaps never produce divergence; but, as separation never produces exactly equivalent sections, it always tends to introduce transformation, through changed or unbalanced action in principles that would otherwise be unchanged and balanced in their action and therefore without transforming influence, and transformation in the separated sections inevitably becomes divergence. We thus gain an explanation of the fact that Isolation, even when accompanied by exposure to the same environments, usually introduces divergent forms of Selection, natural, sexual, social, or dominational, and often new effects from the action of other principles. Independent Generation precedes and determines the possibility of the divergence, and if it is segregative, it also determines in a measure the form of the divergence; but if it is simply separative, the form of the divergence depends on some other principle or principles.

APPENDIX.

Construction of the Permutational Triangle.

In the last chapter of my paper on "Divergent Evolution through Cumulative Segregation" (p. 250) I referred to the Permutational Triangle, which I had constructed to facilitate the solution of a problem there raised in regard to the degree of probability of extinction that would, under certain conditions, result from Segregate Fecundity. The first four lines of the table were obtained by direct observation on the permutations of letters arranged to represent the pairing of animals entirely

THE PERMUTATIONAL TRIANGLE.

Factorials.				*Factors.*	*Occurrents.* (0)	*Concurrents.* Of the first degree. (1)	Second degree. (2)	Third degree. (3)	Fourth degree. (4)	Fifth degree. (5)	Sixth degree. (6)	Seventh degree. (7)	Eighth degree. (8)	Ninth degree. (9)	Tenth degree. (10)
					1						*The*	*Ini*	*tial*	*Num*	*ber.*
$\lfloor 1=$	1=	no. of *occasions.*	in 1st line.	(1)	0	1					*The*	*firs*	*t li*	*ne.*	
$\lfloor 2=$	2=	„	in 2nd	(2)	1	0	1				*The*	*seco*	*nd li*	*ne.*	
$\lfloor 3=$	6=	„	„ 3rd	(3)	2	3	0	1			*The*	*thir*	*d li*	*ne.*	
$\lfloor 4=$	24=	„	„ 4th	(4)	9	8	6	0	1						
$\lfloor 5=$	120=	„	„ 5th	(5)	44	45	20	10	0	1					
$\lfloor 6=$	720=	„	„ 6th	(6)	265	264	135	40	15	0	1				
$\lfloor 7=$	5,040=	„	„ 7th	(7)	1,854	1,855	924	315	70	21	0	1			
$\lfloor 8=$	40,320=	„	„ 8th	(8)	14,833	14,832	7,420	2,464	630	112	28	0	1		
$\lfloor 9=$	362,880=	„	„ 9th	(9)	133,496	133,497	66,744	22,260	5,544	1,134	168	36	0	1	
$\lfloor 10=$	3,628,800=	„	„ 10th	(10)	1,334,961	1,334,960	67,485	222,480	55,650	11,088	1,890	240	45	0	1

lacking in instincts or qualities that secure the pairing together of those of one kind.

For example, let A, B, C represent three females of three varieties of pigeons, and a, b, c three males of the same varieties, all occupying one aviary. Now supposing they are devoid of Segregating instincts, and that they all pair, what are the probabilities concerning the pairing of the males with their own kind? These will be clearly shown by arranging the letters representing one of the sexes in one fixed order, placing the letters representing the other sex underneath in every possible permutation of order. If we make six experiments the probability is that in 2 cases none, in 3 cases one, and in one case 3, will pair with their own kind. These numbers constitute the four terms of the third line. The first, second, and fourth lines were constructed in the same way, but for the construction of the tenth line in this way I estimated that several years of constant writing would be required. The remaining lines here given were therefore constructed according to the following rules, which were discovered by studying the first four lines. The discussion of different methods of constructing the Permutational Triangle, and the interesting properties of the same when constructed, must be deferred; but I may say here that I believe it will be found an important instrument for estimating a large class of probabilities.

A	B	C
a	*b*	*c*
a	c	b
c	a	b
b	a	*c*
b	c	a
c	*b*	a

One method of constructing any line of the Permutational Triangle from the preceding line.

(1) Of any given line, any desired number, except the first, may be obtained by multiplying the preceding number of the preceding line by the factor of the given line and dividing the result by the figure marking the degree of correspondence of the column of the desired number. (2) The first number of any line is one less or one more than the second number of the same line, according as the factor of the line is an odd or an even number.

On the Intestinal Canal of the Ichthyopsida, with especial reference to its Arterial Supply and the Appendix Digitiformis. By G. B. Howes, F.L.S., F.Z.S., Assistant Professor of Zoology, Normal School of Science and Royal School of Mines, S. Kensington.

[Read 20th March, 1890.]

(Plates I. & II.)

CONTENTS.

I. *On the Arteries of the Inferior Mesenteric Series, in the Ichthyopsida.*

The alimentary canal and its appended glands in the Plagiostome fishes receive their arterial supply from three or more trunks arising from the dorsal aorta (Plate I., *ao.*, fig. 1). Of these, the least variable are those which form the extreme anterior and posterior members of the series as hitherto described (*cf.* figs. 7, iii., iv., v.), viz. the so-called cœliac and inferior mesenteric arteries. In addition to these there are usually present two arteries which, unlike the rest, are paired, being derivative of the iliac vessels (*a.i.*, fig. 2); these, the paired nature of which has not before been detected*, pass directly backwards and inwards to reach the posterior wall of the cloaca, in a manner suggestive of the hypogastric arteries of the higher Vertebrata. The vessels alluded to above as "hitherto described" are so well known, and their courses and distribution have been so fully dealt with by Monro, Hyrtl, Parker, and others, that detailed reference to them here is unnecessary. The distribution of the

* Hyrtl has recorded the presence of one (*Raia clavata*) on the left side only (**18.** p. 30).

intervening arteries (the [anterior or superior] mesenteric, lieno-gastric, and anterior spermatico-mesenteric, of authors) * may for the present pass without further comment; the accompanying figures show them (*a.sm.*) to be variable in point of origin and in mutual relationship; not so, however, with the so-called inferior (posterior) mesenteric (*a.sm.* of fig. 1). That vessel invariably arises, in Batoids and Selachoids alike, some distance in advance of the processus digitiformis and so-called rectum (*dv''* and *i.l.* of fig. 1); it lies within the suspensory ligament of these structures and passes obliquely backwards and downwards, to reach the first named of them: on doing this it breaks up to form an elaborate system of vessels which are restricted to the appendix and to portions of the gut immediately adjacent (*cf.* fig. 1). In the long-bodied Selachoids this vessel usually supplies the above-mentioned parts alone; in some of them, however (ex. *Mustelus* [Parker, **27**. p. 701]), as in the laterally extended Batoidei †, it sends branches to the genital glands, as is expressed in Parker's term "posterior spermatico-mesenteric" applied to it ‡. Be the branches and facts of distribution of this artery what they may §, its main trunk is invariably disposed as above described; it is primarily related to the posterior segment of the intestine with its appendage, and its most striking feature is its constant origin at a point remote from these anteriorly—consequent upon which it takes the said backward course.

I have recently published elsewhere ‖ some observations in ichthyotomy that have extended over several years, in connection with which I have had occasion to inject a large number of Skate. While doing so, my attention became arrested by the occasional presence of one or more arteries passing from the dorsal aorta to the intestinal canal posteriorly to the region alluded to above, in addition to the paired vessels already described (*ante*, p. 381). The only mention of such vessels which I have been able to find is one by Hyrtl for the *Torpedo*, in which he

* *Cf.* Hyrtl (**18**), Parker (**27**), and Marshall and Hurst, 'Practical Zoology,' ed. 2 (London, 1888), pp. 234 *et seq.*

† *Cf.* fig. 1, *a. g.*, and Parker's 'Zootomy,' p. 62, fig. 20.

‡ **27**. p. 701.

§ It distributes branches into the suspensory ligament which lodges it; and, from these, twigs may pass to the genital ducts, especially in the female.

‖ Journ. of Anat. and Phys. vol. xxiv. (n. s. vol. iv.), pp. 407–422 (1890).

describes (18. p. 13) a single very small artery arising immediately in front of the crural vessels and becoming distributed to the cloaca—together with the hinder ends of the kidneys and related vasa deferentia.

Pl. I., fig. 1, represents the parts concerned in one of my specimens (*Raia clavata*, adult ♀), as dissected from the side after injection with French blue. The cloaca of these animals (*cl'*) becomes, as is well known, greatly modified—especially in the female—in relation to the genital ducts (*od.*); these approximate posteriorly in relation to a chamber (oviducal recess, *cl'''*) formed by partial subdivision of the cloaca. The arteries in question lay (*a.im.*) immediately in front of the approximated ends of the genital ducts; they arose between the kidneys, the anterior one leaving the aorta at about the middle of these organs *. These vessels lay, like the so-called posterior mesenteric (*a.sm.*), in the folds of the suspensory ligament of the so-called rectum; unlike that, however, they passed (not obliquely backwards but) directly downwards, at right angles to the long axis of the body. The distance between them was far less than that between the anterior one and the so-called posterior mesenteric. I have, in two instances, detected the passage from the extreme base of the aorta, immediately before the point of origin of the iliac vessels, of a couple of very delicate trunks for the post-cloacal wall (*a.im.*, fig. 1). Similar vessels may be present in *Acanthias*; they arise in the immediate vicinity of the bases of the kidneys, and reach the cloaca posteriorly to the genital ducts. I take them to be the homologues of that vessel referred to by Hyrtl in *Torpedo*. Neither set of arteries supplied (with the exception named above), so far as I was able to ascertain, anything but that portion of the intestinal canal immediately adjacent to its point of origin.

It is clear from the foregoing that any comparison which shall now or in future be instituted between the arteries of the posterior portion of the Skate's intestine and those of the corresponding parts in other Vertebrates must take into consideration

* In one specimen observed, the anterior renal artery of the exposed side arose at this point together with the intestinal vessel named, from a common trunk. I am indebted to my demonstrator, Mr. M. F. Woodward, for the knowledge of a specimen (*Raia maculata*, ♀) in which the posterior renal artery of either side gave off a vessel to the cloacal wall, a short distance behind the oviduct.

two sets of trunks—an anterior set (the so-called inferior [posterior] mesenteric) (*a.sm.*, fig. 1), arising in advance of the gut and passing obliquely backwards; and a posterior set, arising in the immediate vicinity of the gut and passing directly downwards. The alimentary tract of the higher Vertebrata receives its arterial supply from two sets of vessels—an anterior set (the cœliac and superior mesenteric arteries), which arise close together or from a common trunk; and a posterior (the inferior mesenteric artery or arteries), which arise far back and pass either directly downwards or but little obliquely backwards or forwards. These well-known facts at once suggest homology between the smaller vessels which I have herein described for the Skate (*a.im.* of fig. 1) and those of the inferior mesenteric series as ordinarily understood. The lack of oblique disposition is not, however, the only distinctive feature of these vessels. Those arteries known in the higher Vertebrata as the inferior mesenteric are so called from at least an analogy to the single vessel to which the term was first applied in mammals *. The inferior mesenteric artery of the Mammal supplies the rectum and the posterior section of the colon alone—it supplies, that is to say, the posterior portion of the large intestine; be this viscus relatively short (as in the Cat and Dog), or relatively long (as in the herbivorous mammals), the trunk of the inferior mesenteric artery never undergoes marked displacement either in a backward or forward direction. Such adaptive change as this vessel exhibits is of the nature of an extension of its branches along the dorsal wall of the gut, without displacement of its main trunk.

That the above remarks apply equally to most Amniota can be readily proved on appeal to the works of leading authorities. Among the Ichthyopsida, however, the recognition of a similar condition of the arterial supply has, to a great extent, escaped notice. To take a leading example, *i. e.* the Common Frog. In that animal, as is well known, the alimentary canal receives its arterial blood for the most part from a single cœliaco-mesenteric trunk; this supplies that viscus with its appendages from the post-œsophageal region to the middle of the large intestine (*cf.* Wiedersheim **8.** Abth. ii. pp. 76–77). There arises from the aorta, almost immediately in front of its point

* It is said to be absent in the *Didelphia* (Owen, **25.** p. 541) and *Monotremata* (Owen, **24.** p. 391); Hyrtl denies this (**17.** p. 7) for *Ornithorhynchus*.

of bifurcation, a well-marked vessel (*a.im.* fig. 4 *a*, *im.* iii. fig. 2), which passes directly downwards, or but little obliquely backwards, for distribution to the immediately adjacent wall of the large intestine. That viscus (*i.l.*) is in this animal, as in the Ichthyopsida generally, very short; and the vessel in question supplies its posterior half—supplies, that is to say, that portion of it which in the Mammalia becomes differentiated into at least the rectum; it has been termed by Wiedersheim, who first described it (**8.** Abth. ii. p. 77), the "*Arterie mesenterica inf. oder A. hæmorrhoidalis superior*," and by Marshall (**22.** p. 29) the "*hæmorrhoidal artery*." Inasmuch as it agrees, in every detail, with the inferior mesenteric artery of the Mammalia and higher Sauropsida (and especially with that of man to which the term "inferior mesenteric" was first applied), it must be similarly named *. An unfortunate confusion has arisen between its main trunk and the superior hæmorrhoidal artery of the higher Amniota, which is but a branch of its homologue; and the burden of proof that it represents this branch alone lies with those who have, as I believe, wrongly identified it.

Turning from the Frog to the Salamander, we find usually four such vessels represented (*a.im.*, fig. 5). These were first described by Hyrtl †, and subsequently by Rusconi (**30.** pl. vi. fig. 1), who confused them with the efferent veins of the cloaca; he, however, figured them with perfect accuracy, and they have been more recently diagrammatically represented by Wiedersheim (**33.** p. 715, fig. 550 B). Hyrtl has described in *Proteus*, *Siren* (*l. c.*), and *Cryptobranchus* (**19.** p. 109) a series of vessels having similar relationships. On examination, these arteries are seen (fig. 5, *a.im.*) to agree, in origin and distribution, with the inferior mesenteric artery of the Frog and of the Amniota on the one hand, and with at least the anterior two of the four vessels herein described for the Elasmobranchs on the other.

In all these animals individual variations affect, among other parts, the arteries under consideration; and, in the case of the Frog, the former have hitherto escaped notice. Fig. 3 combines the invariable condition met with in that animal (*a.im.* iii.)

* Wiedersheim figures it (*op. cit.* p. 77, fig. 37), in error, as distributed to the urinary bladder. I have never observed this arrangement. The allantoic bladder of the Amphibia receives its arterial supply, as does its homologue among the Amniota, from the iliac vessels.

† Cf. "*Lepidosiren paradoxa*," Prag, 1845, p. 39.

with such variations as I have from time to time observed (*a.im.* i. ii.). In one specimen (an adult ♀) there arose from the aorta, a short distance in advance of the artery (iii.) normally present, a single trunk (i.); this gave off, soon after its origin, a small branch to the oviduct of the left side, but its main trunk ran on to be distributed to the immediately adjacent wall of the large intestine. In two other examples (both males) I have noted the presence of two arteries (ii.) which, like the foregoing, passed at once to the adjacent intestinal wall; they differed from the last-named only in their relative slenderness, and in their exclusive restriction to the large intestine. The identity of these vessels with those of the Salamander is most striking, and when the parts under consideration in these animals and the fish are (as delineated in Pl. I. figs. 1, 3, and 5) reduced to the same size, the point of origin of the anterior of the series is seen to coincide throughout. Wiedersheim speaks of these vessels (33. p. 715) in the Salamander as arteries of the rectum ('Mastdarm'): in that they supply the greater portion of the large intestine, this term is insufficient—for, on the assumption (which can hardly be open to doubt) that the large intestines of the Amphibia and Amniota are homologous, they supply that section of the same which, in the ascending series of Vertebrata, becomes differentiated into the rectum and greater portion of the colon. Here the mind again reverts to the Mammal, and demands the declaration of homology between these vessels and the inferior mesenteric artery of it and of the higher Amniota, as the logical sequence to the facts.

The area of distribution of the single inferior mesenteric artery of the higher types being shown to coincide with that of the series in the Amphibia (and Thornback), the question immediately arises whether the condition of the first-named may not have arisen, either from a collecting together of the several trunks, or from atrophy of certain of the same, wholly or in part. The leading branches of these vessels usually lie, in the Salamander (fig. 5), along the dorsal middle line of the intestine; they there anastomose freely to form a generally well-defined longitudinal vessel, from which the side branches arise. In view of this, the obliteration of, say, the three anterior trunks of the series, between the aorta and the intestinal wall, would give us a condition identical with that of the higher types (cf. *ante*, p. 384); and it is conceivable that that realized in the latter may have arisen in

some such manner. I have met with individual Salamanders in which the arteries in question were reduced in number. The most striking example was one in which two, instead of four, main trunks were represented (fig. 6, *a.im.*); of these, the anterior one occupied the position and had the relationships of the anterior of the four more normally present, while the posterior one coincided in origin with the normal second artery, but partook of the distribution of the posterior three usually present (*cf.* fig. 5). These facts appear to me to indicate an origin of the single artery of the higher forms by concrescence such as I have postulated; and, in further support of a belief in the same, attention may be directed to the greater calibre of the posterior of the two arteries (fig. 6) in the Salamander*, and to an individual Frog (♀, fig. 4), in which the single artery present suddenly divided almost immediately after leaving the aorta (*ao.*).

II. *On the Arteries of the Cœliac and Superior Mesenteric Series, in the Ichthyopsida.*

I claim to have shown, in the foregoing, that those arteries which in the Ichthyopsida supply the posterior segment of the large intestine are serially homologous with the inferior mesenteric of the higher forms, and that the leading feature of these, taken collectively, is the invariable disposition of their main trunks at right angles to the axis of the body. In respect to this they contrast most forcibly with the great arteries which supply the rest of the alimentary canal; those generally arise far forwards, either from a single trunk (cœliaco-mesenteric) or from two (cœliac and superior [anterior] mesenteric) or more (cœliac, lieno-gastric, mesenteric, spermatico-mesenteric) trunks well known (*cf.* Hyrtl **18**, Parker **27**, and fig. 6, i. to v.).

The terminal portion of the intestine of the Plagiostome fishes is well known (*cf.* fig. 1) to be destitute of intestinal valve; it leaves the body in a straight line, becoming enlarged posteriorly to form the cloaca (*cl'*). To this valveless segment of the gut Monro applied (**23.** p. 94) the term "great gut," but that of "rectum" has been since more generally allotted it, apparently on a supposed homology with the rectum of the higher Vertebrata

* Wiedersheim figures an anastomosis between the third and fourth of the series (**33.** p. 715, pl. 550 B).

(*i. e.*, and more especially, of the Mammalia). Nearly all previous observers have agreed in regarding it either as a portion or the whole of the large intestine. It is characteristic of that part of the large intestine which, in the higher Vertebrata, lies immediately in front of that related to the inferior mesenteric vessels, that its nutrient arteries arise at a point remote from it anteriorly (*cf. ante*, p. 384); exceptions occur (ex. *Salamandra*, Pl. I. fig. 5), but, even in such, a wide interval is recognizable between the vessels in question and those of the inferior mesenteric series (*a.im.*). Either the posterior artery of this set (where more than two exist) or the most posterior branch thereof (where either one [*Rana*, most *Teleostei*] or two [*Raia*] exist) invariably supplies, in the higher Ichthyopsida and Reptilia *, the head of the large intestine, with a more or less considerable portion of the adjacent base of the ileum. That to which I here refer as the "head" of the large intestine includes so much of that viscus as is not supplied by the inferior mesenteric vessel or vessels (*i. e.* the short cæcum and that which in the Mammalia becomes the greater portion of the colon).

On turning to the Plagiostome fishes, a considerable variation becomes manifest (fig. 7, i. to v.) in the number and arrangement of these vessels. There are never more than three present, as ordinarily enumerated; four are indicated in the accompanying diagram (fig. 7, iii., iv., v.), but the terminal one of the series is usually excluded from the category, having been likened by Hyrtl, whose nomenclature has been hitherto everywhere adopted, to the inferior (posterior) mesenteric. As such this vessel is customarily described. Herein there lies a contradiction; for if it be true, as I claim to have shown (*ante*, p. 386), that the inferior mesenteric artery of the higher Vertebrata, with which it has been compared, is one of a series characterized, in all its variations, by the fact that its members do not arise at a point anteriorly remote from that portion of the gut which they supply, this vessel must be removed from that category, and the term "inferior mesenteric" will become inapplicable to it. Hyrtl's determination was based upon an examination of the vessels of

* *Cf.* Hoffmann, **14.** p. 1574. The term "inferior (posterior) mesenteric" has here been applied to that which clearly represents the vessel so named by Hyrtl in the Elasmobranchs, those which represent the inferior mesenterics of the Amniota and Amphibia being termed rectal arteries (*cf.* pl. cxxxv. fig. 1).

the *Batoidei*. On reference to fig. 7, ii., which represents the origins of these in the Thornback (*Raia clavata*), it will be seen that the cœliac (*a.c.*) and superior mesenteric, as ordinarily described, arise far forwards and close together, as in the majority of the higher Vertebrata, and that the so-called inferior mesenteric (the right of the two lettered *a.sm.*) arises far behind them, in a manner certainly suggestive of the mammal itself, and such as might appear, were it true of all Plagiostomes, to justify this comparison. In those Selachii of whose arteries we possess a sufficient knowledge, the cœliac and superior mesenteric arteries of the Batoids are represented by three trunks (fig. 7, iii. to v.—the cœliac; superior, anterior, or anterior spermatico-mesenteric; and the lieno-gastric, of authors). In *Acanthias* the two last named arise far back (v.), in close proximity to that which Hyrtl likened to the inferior mesenteric trunk.

Acanthias (fig. 7, v.) and *Raia* (ii.) represent the extreme terms in the Plagiostome series, so far as our knowledge of the arteries of their alimentary canal goes. The origins of the latter are indicated to scale in the accompanying figures, and it will be seen that there is a constancy of relationship between the cœliac and so-called inferior (posterior) mesenteric vessels—the latter shifts its position only in the Batoid, in which it is dragged forwards, as it were in sympathy with the superior mesenteric, which lies in close proximity to the cœliac *.

No competent anatomist would hesitate to relegate the cœliac and superior mesenteric arteries of *Raia* (fig. 7, ii.), as ordinarily described, to a common category; nor would he, on first examination of *Acanthias* (fig. 7, v.), hesitate to similarly associate the two arteries of the superior mesenteric series † with that termed by Hyrtl and subsequent writers the "inferior mesenteric." Herein lies the whole difficulty—are we justified in longer referring, with Hyrtl, the vessel in question (*a.sm.* of fig. 1), to the inferior mesenteric series?

In *Scyllium* (fig. 7, iv.) we meet with a condition essentially transitional between the two extremes above mentioned (*Raia* ii. and *Acanthias* v.), inasmuch as the superior mesenteric arteries

* I suspect that the changes incident upon the lateral extension of the body, with its attendant abbreviation from behind forwards, may be here active.

† I refer to these vessels as such for brevity, and in no want of respect for either the work or nomenclature of my contemporaries.

arise very nearly midway between the cœliac and Hyrtl's "posterior mesenteric." The dotted line α—β of the figure will testify to the truth of the assertion that, with respect to the origins of these arteries, a gradational series is forthcoming among easily accessible forms; and, on the knowledge of that which has gone before, we should be justified in removing the so-called "inferior" or "posterior" mesenteric artery of the Plagiostomes from that category, and relegating it to that of the superior mesenteric series.

The inferior mesenteric arteries of those Ichthyopsida least remote from the fishes (*i. e.* the *Urodela*) are usually four in number, and I have attempted to show (*ante*, p. 387) that the reduction in number of these vessels met with among the higher forms (ex. *Rana* 1 to 3, *Lacerta* 2 to 3, *higher Amniota* 1 or more) may, in all probability, have been due to modification of such a series by concrescence. In view of the variation of the cœliaco-superior-mesenteric arteries before referred to, one is led to ply the same question, viz.: may not they be the modified derivatives of a closely related series? That they are liable to concrescence at the present day cannot be doubted, since, in *Acanthias* (fig. 7, v.), it occasionally happens that the mesenteric and lieno-gastric trunks unite. Among the *Urodela* we meet with a condition of the arteries of the cœliaco-superior-mesenteric series in which (*Salamandra*, fig. 5) the several trunks lie (*a.cm.sm.*) closely aggregated side by side. The most recent account of these is that given by Wiedersheim (**33.** p. 175). Hyrtl has long ago described them, as also a similar series in *Proteus*, *Siren*, and *Cryptobranchus* (cf. *ante*, p. 385); Hoffmann alludes to them (**13.** pp. 493–494) as the arteriæ "gastrica anterior," "gastrica mesenterica," and "mesenterica primæ et accessoriæ." Wiedersheim figures, in *Salamandra*, six main trunks; I find seven to be the usual number * (fig. 5, *a.cm. sm.*). Be there six or seven present, the posterior one invariably supplies the head of the large intestine; in its relationships to the inferior mesenteric vessels it stands identical with the so-called hæmorrhoidal branch of the Frog's superior mesenteric on the one hand, and with the so-called inferior or posterior mesenteric of the Plagiostomes on the other. The arteries of this very interesting

* Hyrtl enumerates from 13 to 17 for the collective series in the Urodeles referred to.

Salamandrine series differ from the corresponding vessels of other Vertebrata only in the fact that their main trunks show but little signs of forward displacement. In that they leave the dorsal aorta nearly at right angles to the long axis of the body, they approximate towards the condition of the inferior mesenteric arteries (cf. *ante*, p. 388); there is, however, a very marked gap * between the two sets of vessels, and, of the two, the anterior are by far the most closely aggregated (*cf.* fig. 4). Fusion of these, more or less marked, would give us the varying conditions met with in the other Vertebrata. I have satisfied myself that reduction in their number, such as that figured by Wiedersheim (*loc. cit.*), results either from fusion of a couple of the anterior mesenteric trunks (*a.sm.*), or from confluence between the most anterior of these and the cœliaco-mesenteric artery (*a.cm.*). In this we have evidence of a process of change identical with that to which the facts concerning the inferior mesenteric vessels appear to point (cf. *ante*, p. 387); taken in conjunction with that above described in *Acanthias* (p. 390), it points unmistakably to the conclusion that the less numerous cœliac and superior mesenteric arteries of the other Vertebrata may have arisen (as I have attempted to show for the inferior mesenteric) from a more numerous series, by concrescence. If I am right in referring the posterior mesenteric artery of the Plagiostome fishes to this cœliaco-anterior-mesenteric series (and this, in the long run, is the leading conclusion for which I am contending, so far as the blood-vessels are concerned), Hyrtl's observation (**18.** p. 13), that in *Torpedo* it is represented by two arteries which proceed side by side to the processus digitiformis and adjacent parts, is very welcome; for it suggests that in that which I would term the supernumerary vessel we may, in all probability, be dealing with the representative of one which has been lost in the allied forms. The arteries of this series vary in number, in the Salamander, from seven to six; in the knowledge of the fact discovered by Hyrtl they do so, in the Plagiostomes, from five to three; and when it is seen that they are to-day showing signs of concrescence (cf. *ante*, p. 390), we are enabled to point to the existence of a gradational series which very strongly favours the conclusion that the vessels repre-

* This appears to have been exceptionally marked in the individual figured by Wiedersheim (**33.** fig. 550 B).

sentative of the same in the majority of living Vertebrates *may* have arisen, by concrescence, in a manner analogous to that of the allied inferior mesenteric set *. Moreover, the retention, among the tailed Amphibia, of that which would appear to be the lowest stage in the development of the intestinal arteries becomes the more interesting and suggestive in view of the lowly condition of the urinogenital organs of these animals †.

From the foregoing I would deduce the belief (i.) that the leading arteries of the alimentary canal of the Vertebrata may be resolved into two well-marked series—(*a*) that (including the cœliac, superior or anterior mesenteric, lieno-gastric, and spermatico-mesenteric arteries of authors, together with the so-called inferior or posterior mesenteric of the Plagiostomes) which I would propose to term the *anterior splanchnic series*; and (*b*) that embracing the inferior mesenteric arteries as herein defined (*ante*, p. 388), for which the term *posterior splanchnic series* may suffice: (ii.) that the two series of arteries are always separated by a more or less wide interval, which increases in proportion as each becomes modified by concrescence: and (iii.) that such modification, although common to the two series, affects the posterior one in the least marked degree ‡. The vessels of the anterior splanchnic series supply the alimentary canal and its appended glands from at least the base of the œsophagus to the head of the large intestine, where such can be definitely recognized; while those of the posterior series are invariably restricted to the posterior portion of the large intestine (colon in part and

* It is pertinent to remark here that examination of a series of individuals of our commonest Ichthyopsida will generally reveal facts of similar significance. In the *Gadidæ* it is the rule to find the cœliac and superior mesenteric arteries arising conjointly (*cf.* Johannes Müller's 'Myxinoiden,' Fortsetzg. 3, pl. iii. fig. 13, and Stannius's 'Anat. d. Wirbelth.,' Zweite Aufl. p. 245); but individuals in which they arise independently daily reach our laboratories (*cf.* Parker, 'Zootomy,' p. 113, fig. 32). Similarly, individuals of the common Frog occasionally present themselves in which an identical condition may be seen (*cf.* Huxley & Martin's 'Practical Elem. Biology,' revised ed. 1888, p. 87).

† *Cf.* Balfour, "On the origin and history of the Urinogenital Organs of Vertebrates," Journ. Anat. & Phys. vol. x. p. 28 (1876), and Jungersen [20], pp. 192 *et seq.*

‡ The facts obviously suggest a likeness to the metameric symmetry of the offshoots of the intestinal vessels of the segmented worms; but further speculation under this head would be now premature.

rectum, when differentiated, with the cloaca). The posterior series appear to be wanting only when (espec. *Teleostei, Marsupialia*) the anterior splanchnic ones supply the entire viscus. Whether this condition results from the suppression or absence of the posterior series, or from anastomosis between it and the anterior, there is, at present, no evidence to show. I have examined a large number of Teleostei, in vain, in the hope of finding, in that order, a more general development of the inferior mesenteric trunks, as defined by myself.

III. *On certain Appendages of the Intestinal Wall of the Ichthyopsida, in relation to their Arterial Supply.*

If the foregoing considerations are sound, it will follow that the so-called inferior mesenteric artery of the Plagiostomes (*a.sm.*, fig. 1) really represents that vessel (the posterior vessel of the anterior splanchnic series) which is normally distributed to the head of the large intestine with its adjacent parts, in the higher Vertebrata. If this be so, that which we, in the Plagiostome fishes, customarily regard as the rectum, would appear to represent the entire large intestine together with a portion of the small one, as defined for the terrestrial Vertebrata.

The most conspicuous structure present in this region of the Plagiostome's gut is the *processus digitiformis* * (*dv''*, fig. 1). On comparison with the Frog † (fig. 4) or with a Lizard ‡, this struc-

* Better known as the "rectal gland" ("bursa cloacæ" of Retzius). I prefer to exclude these terms from the text, for reasons which the sequel will show.

† That the Frog possesses a rudimentary cæcum is at once clear on comparison with a Lizard. If the head of the large intestine be opened from the side, as represented in fig. 3, it will be seen that the ileum enters that viscus from below; a line drawn vertically through the valvular extremity of the ileum will pass behind an overhanging enlargement of the antero-dorsal wall of the large intestine, and that this represents the cæcum coli is clear on consideration of the well-known facts of morphology of that structure.

The discovery of the Frog's cæcum has been attributed to myself, in error (Wiedersheim [33], p. 564). I was the first to figure it ('Atlas of Practic. Elem. Biology,' 1885, pl. 1. fig. 13); it was originally described by Huxley in Huxley and Martin's 'Elem. Biology,' original ed. p. 166 (1875).

‡ *Cf.* Parker, 'Zootomy,' p. 164 and fig. 40.

ture, when viewed in relation to the intestine on the one hand and the arteries on the other, is found to answer precisely to the appendix vermiformis of the Mammalia. Like that, it forms a glandular appendage to a diverticulum of the mid-dorsal intestinal wall; like that, it receives its arterial supply from the most posterior offshoot of the superior mesenteric artery. There is here raised the most revolutionary point in my investigation; and the suggestion would appear, at first sight, to be negatived by the mode of origin of the diverticulum in question in the Plagiostomes, from the middle instead of the anterior extremity of that which, in them, we are accustomed to regard as the rectum or large intestine. It must not be forgotten, however, that the application of the terms "rectum" and "colon" to the intestines of fishes implies only a conception of rude analogy to the parts so named in the Mammalia.

The appendix digitiformis consists of either a digitiform, as its name implies (Pl. II. figs. 8–14), or a slightly coiled structure (*Rhina*, fig. 15), which communicates with the gut by means of a more or less well-marked duct (*dv'*). It has been described in a general way by various observers for different genera and species*; but neither the gland nor its duct have thus far received the attention which they merit. That the gland arises as a diverticulum of the intestinal wall is clear from the researches of Blanchard (2) †. The intestinal spiral valve of the Plagiostomes usually terminates at a point remote from the origin of this appendix digitiformis and its duct (ex. *Raia*, fig. 1, *v.i.*). Parker has recorded (26) for the valve, in this and other Elasmobranchs, an astonishing range of individual variation in its mode of disposition and total area; he has failed, however, to lay sufficient stress upon the striking nature of the same in relation to its point of termination posteriorly. In the adult Skate, for example, it may either terminate at a point much farther forwards than that represented in fig. 1 (*cf.* Parker, *l. c.* pl. 10. figs. 1 & 8), or at that marked * in the same, thus diminishing the distance between its posterior extremity and the orifice of the duct of the appendix digitiformis. In *Notidanus* (*Heptanchus*) the valve extends still further back, and terminates, in a slightly interrupted but exceedingly definite manner (fig. 14, *v.i.*), immediately in front of the

* For *résumé* see Duméril (7), pp. 157, 158.

† My attention was first drawn to this paper by my friend Dr. Hans Gadow.

orifice just alluded to *; while in *Cestracion* it does so at a point situated lineally with this below.

That the spiral valve performs an absorptive function can hardly be doubted after the investigations of Edinger (**9**. p. 678) into its histological structure. That segment of the intestine which bears it comes thus to represent most nearly the ileum † of the higher Vertebrata; and, inasmuch as the valve may extend back to the point of origin of the "duct" of the appendix digitiformis (*dv'*, fig. 14), that portion of the gut lying immediately in front of the latter can consequently be most satisfactorily compared only with the small intestine. The application to it of the term "rectum" is no longer justifiable; and the above facts warrant the restriction of the term "large intestine" to so much of the gut as is situated behind the duct referred to (= that portion embraced by the lines radiating from *i.l.* in fig. 1). If this be admitted, the comparison, before instituted (*ante*, p. 394), between the appendix digitiformis and its duct and the appendix vermiformis and cæcum, becomes vastly strengthened, and these two sets of structures may justly be alike regarded as median diverticula of the antero-dorsal extremity of the large intestine.

Parker's researches show (**26**), when looked at critically, that the spiral valve varies, among Elasmobranchs generally, in nothing more conspicuously than in its degree of abbreviation from behind forwards. The belief in the primitive characters of the living *Notidanidæ* is becoming more and more justifiable from the researches of palæontologists ‡; and we may therefore attach a special importance to the great development of the spiral valve in *Heptanchus* (cf. *ante*), as it furnishes us with a condition from which, so far at any rate as backward extension

* Such does not appear to be the case in the allied *Chlamydoselache*. *Cf.* Garman (**10**) and Günther (**11**).

† Home alluded to it (**15**. p. 391) as the "jejunum." It is exceedingly unfortunate that in students' books current it should be spoken of as the "colon" (Marshall and Hurst's 'Junior Course in Practical Zoology,' ed. 2, 1888, p. 219).

‡ *Cf.* A. S. Woodward, P. Z. S. 1886, pp. 218–224, and Geol. Mag. dec. iii. pt. iii. 1886, pp. 205 *et seq.*

Haswell has still further emphasized the belief, in his proposal (Trans. Linn. Soc. N. S. W. vol. ix. pt. i. p. 44, 1884) to subdivide the Selachoidei, in accordance with the great diversities in their skeletal anatomy, into the two suborders of the *Palæoselachii* (*Notidanidæ*) and *Neoselachii*.

It is worthy of remark that the spiracular gill of these Sharks, although a

is concerned, there may be derived that met with in all other living *Plagiostomi*.

It remains now to consider, more closely than heretofore, the differences and resemblances between the appendix digitiformis and its "duct" and those structures to which the terms cæcum coli and appendix vermiformis have been applied. The appendix digitiformis lies to the left side of the valved intestine, as pointed out by Blanchard (**2.** p. 190) *, and its apex is, in the adult, usually directed towards the animal's right. Examination of it in relation to the lumen of the gut shows it to be, however, a derivative of the mid-dorsal intestinal wall. On opening the body-cavity from the ventral aspect in the Common Skate, the structure in question is seen to occupy the interspace between the pyloric sac of the stomach and the adjacent intestine, and to be disposed lineally with the former. Anteriorly it is received into a notch in the posterior border of the pancreas. Such may be the disposition of the cæcum among certain of the higher Vertebrata, and in *Rana* and *Lacerta* that organ, if examined with sufficient care, may generally be found to lie at or towards the side †.

The appendix digitiformis and its "duct" are, like the appendix vermiformis and cæcum coli, extremely variable in development in even allied forms ‡. Figs. 8 to 14 represent the former in

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"pseudobranch" as recently defined by Sagemahl (Morphol. Jahrb. t. x. 1885, p. 113), has just been shown by Virchow (Verhandl. d. physiol. Gesellsch. Berlin, 1889–90 [Archiv. f. Anat. u. Phys., Phys. Abth. 1890, pp. 170 and 178 *et seqq.*]) to differ from that of all other Chondrichthyes in having the essential structure and the capillary networks of a true demibranch; and it is difficult to believe, in view of his researches, that it can be other than respiratory in function.

* In *Læmargus* this is so markedly the case that the suspensory mesentery of the gland shifts its position, and becomes attached obliquely across the antero-dorsal moiety of the same.

† This fact would appear to account for the representation of the same as a diverticulum of the ventral wall of the gut (cf. *Rana* [Marshall, **22.** p. 27, fig. 5] and *Amphisbæna* [Bedriaga, **1.** pl. iv. fig. 2]).

‡ Blanchard has directed attention to this (**2.** p. 182) so far as the appendix digitiformis is concerned. He gives as the minimum length observed 0·8 centim. (*Chiloscyllium plagiosum*, length of body not stated). In a *C. ocellatum* of 46 centim., recently captured by my friend Prof. A. C. Hadden in the Torres Straits, and by him generously placed at my disposal, the gland measures 0·6 centim.

typical examples, drawn to the same scale relative to the transverse diameter of the base of the adjacent intestine (α—β of Pl. II. fig. 14). These structures show, so far as I have been able to ascertain, little sign of individual variation: the first noticeable features concerning them are (i.) that the length of the duct bears little or no proportion to either the length or bulk of the gland—the latter is most massive in *Læmargus* (*dv''*, fig. 10), where the duct (*dv'*) is shortest; and (ii.) that the maximum attenuation of the gland is not accompanied by that of the duct (cf. *Acanthias*, fig. 13, and *Notidanus*, fig. 14). This "duct" has been previously best described by Home* and Blanchard. The last-named author regards it (*Acanthias*, **2.** p. 182) as a duplicature of the intestinal mucous membrane. It is more or less marked in all the *Selachoidei* which I have been able to examine; and it will be seen from the accompanying figures that it attains its greatest attenuation in *Notidanus* (fig. 14); between the conditions exemplified in this genus and in *Læmargus* (fig. 10), taken as extreme terms in the series, gradational types present themselves in *Scyllium*, *Cestracion*, and *Acanthias* (figs. 11, 12, 13). On examination of these, the duct in question (*dv'*) might readily appear to have been formed by a downward extension of a simple fold of the intestinal wall, such as that of *Læmargus* (fig. 10). *Læmargus* is remarkable for the possession of the most aberrant type of intestinal canal met with in living Plagiostomes. Its duodenal segment is, unlike that of all other Elasmobranchs, tubular and flexed, and the bearer of a couple of enormous diverticula which Turner has (**31.** p. 245) compared to the pyloric cæca of the *Osteichthyes*; its appendix digitiformis (fig. 10) is the most massive that has yet been observed; and, in view of the facts just named, it becomes doubtful whether that structure may not be in a much modified condition.

In the *Batoidei* the processus digitiformis communicates with the intestine by a short non-constricted passage (*dv'*, fig. 1), little suggestive of the "duct" of the Selachoids. Monro has already figured this in *Raia*†, and I find an identical condition in *Torpedo*, *Trygon*, and the rare *Hypnos subnigrum*. Comparison of figs. 1 and 3 at once suggests an homology between

* He naïvely likened the apparatus (**15.** p. 392 [A. D. 1814]) "to the ink-bag in the Cuttle-fishes" (*cf.* his **16.** pl. xcviii.).

† **23.** pl. ix. fig. 2.

this passage (which is in reality a wide funnel-shaped prolongation of the gut) and the cæcum coli of the higher Vertebrata. Comparison of Pl. II. figs. 9 to 14 shows unmistakably that that prolongation (be its original significance what it may) has become converted by constriction into the "duct" of the processus digitiformis of the Sharks; and suggests that the *Batoidei* in all probability retain a more primitive condition thereof than do the *Selachoidei* of to-day. Attenuation of the "duct" has been seen (*ante*, p. 397) to be most marked in *Notidanus* (*dv'*, fig. 14). Thanks to the generosity of Prof. Huxley, I have been enabled to examine a fœtal *Notidanus** measuring 15 centim. in total length. In it the duct is much shorter and relatively wider than in the adult, and in no way bound down to the intestinal wall; it stands out from this in the manner indicated in fig. 8 (*Zygæna malleus*). In *Zygæna* this condition is retained; and it will be observed that it is just such as would result from elongation of the intestinal diverticulum of *Raia* (fig. 9) with accompanying constriction. *Squatina* ([*Rhina*], fig. 15) is, in respect to this constriction, transitional between *Raia* and *Zygæna*. That the *Selachoidei*, in which this structure becomes most modified, pass through a stage such as is here represented is clear from the condition of the young Notidanid; and in the absence of further embryological data I can only conclude that the *Batoidei* do present us with the least modified condition of the parts, and that the duct-like base of the appendix digitiformis seen in them is the representative of a structure closely comparable to, if not homologous with, the cæcum coli. Whether that portion of this "duct" which, in the *Selachoidei*, skirts the wall of the gut is a superadded passage formed from behind by a duplicature of the mucous membrane, as Blanchard supposes (**2**. p. 182), has yet to be proved; from the facts herein recorded, I incline to the belief that it is not, but that the apparent superaddition may have resulted from adhesion.

The processus digitiformis is, as Duméril has remarked (**7**. p. 158), "a true secretory organ." Its secretory glands have been compared by Leydig (**21**. p. 57) to those of Brunner, met with in the mammalian intestinal wall; and he calls attention to the "dirty yellow" nature of their product. Blanchard has attempted to institute (**2**. p. 181) comparisons between the secre-

* That alluded to by him in P. Z. S. 1876, p. 44.

tion of this gland* and that of the "anal or circum-anal glands of many higher animals;" and he accordingly proposes to term it the "*glandula superanalis*" (*l. c.* p. 182). To English students this structure is best known as the "rectal gland." Blanchard's researches seem to point to its origin as an outgrowth of the hypoblastic gut; those structures which we commonly term "rectal" or "anal" glands, are associated with the terminal epidermal portion of the hind gut, and it is tolerably safe to conclude that from this they are developed. Proof that this is so does not appear to be at present forthcoming; but the facts to which I have alluded warrant the withdrawal of the term "rectal gland" in the case of the *Plagiostomi*.

The appendix digitiformis has been by Hyrtl regarded (**18.** pp. 28–29) as accessory to the reproductive apparatus rather than to the alimentary. He based his assumption † upon the failure to find food-stuff within it, and upon a belief in its increase in size in animals whose oviducts contained eggs. I have examined a series of specimens of *Raia* and *Mustelus* having eggs and young in their oviducts, in vain, for confirmation of Hyrtl's belief; and confidence in the same is further shaken by the fact that his views fail to explain the presence of the organ in the male in a form indistinguishable from that of the female. Moreover, the course taken by its duct, and the fact that its secretion is discharged well forwards into the intestine, would appear to be irreconcilable with this view. In the fact that this organ is a secretory one, we have, in the long run, a further point of agreement with the cæcum coli and appendix vermiformis. The fact that the latter becomes an adenoid in its most highly differentiated form, while the processus digitiformis is not known to be thus constituted ‡, would appear to be of minor significance, by analogy with Weldon's discovery (**32.** p. 176) that

* On p. 181 of his pamphlet, Blanchard attributes to Milne-Edwards (Anat. et Phys. Comp. t. vii. pp. 326, 332) the belief that this structure represents "a special urinary bladder." M. Milne-Edwards makes ("in seinem trefflichen Lehrbuch" [Blanchard, *l. c.*]) no such statement; he alludes not to the appendix digitiformis, but to the well-known urinary receptacle, which I have elsewhere proposed to term the Wolffian bladder (Journ. Anat. & Phys. vol. xxiv. [n. s. vol. iv.] p. 408, 1890).

† Blanchard (*l. c.*) appears to have been unaware of this.

‡ Migratory leucocytes have been observed in the "cloacal epithelium" of *Raia*, *Torpedo*, and *Squatina* (List, J. H., "Studien an Epithelien," Archiv f. mikr. Anat. Bd. xxv. pp. 264–268, 1885).

the supra-renal body in the Ichthyopsida (*Bdellostoma*) probably represents a metamorphosed excretory blastema.

I trust to have shown in the foregoing that the appendix digitiformis and its related conduit correspond, in fundamental relationship, with the appendix vermiformis and cæcum coli; and I think it not improbable that in the former, as represented in the *Batoidei* (*cf. ante*, p. 398), we may be dealing with the latter in their original form. It is a curious fact that Monro, in his classical work on Fishes, referred to the appendix digitiformis on one page (**23**. p. 84) as the "appendix vermiformis" and on another (p. 92) as the "cæcum;" while Wiedersheim, commenting (**33**. p. 565) on the size and character of the cæcum coli of *Amphisbæna* *, has incidentally likened it to the appendix digitiformis of the Selachii. I would go further, and openly declare a belief in homology between the two sets of structures as defined by myself (p. 394) until proof to the contrary, more conclusive than that which is at present forthcoming †, shall have been brought forward.

IV. *On the Cæcum of the Teleostei.*

It is customary in text-books to deny the existence of a cæcum among the Teleostean fishes. Such an organ was, however, accorded them by Home in 1814 (*Scorpæna* [**15**. p. 389, **16**. pl. xcii.]); Rathke, ten years later, described ‡ a cæcum in *Cyclopterus* ("See Hase") and *Trigla lyra*, while Cuvier and Valenciennes accredited the same (**5**. p. 354) to *Box* in 1830.

* On examination of this in *Lepidosternon*, *Blanus*, *Pachycalamus*, and *Amphisbæna* (*alba*, *fuliginosa*, and *darwinii*), I fail to see anything much in advance of the ordinary Lacertilian type.

† The danger of drawing comparisons from the histological structure of the alimentary mucous membrane alone is greatly increased by the discovery of thickly set Peyer's patches in the large intestine and rectum among Rodents, Insectivores (Dobson, Journ. Anat. & Phys. vol. xviii. pp. 388–392, 1884), and Apes (*Hapalemur*, Beddard, P. Z. S. 1884, p. 395). A similar caution is necessitated by Weber's description of racemose sudoriferous glands in the *Hippopotamus* ("Studien über Säugethiere," Ein Beitrag zur Frage u. d. Ursprung d. Cetaceen, pp. 14–18, Jena, 1886).

‡ **29**. pp. 80, 81. He also attributed to *Polypterus* a cæcum, with the comment "wen ich mich richt erinnere." There can now be little doubt that Joh. Müller was right in subsequently regarding this ('Bau u. Grenzen der Ganoiden,' p. 23) as a pyloric cæcum; for, among Teleostei, the cæca pylori may be reduced (*Ammodytes*, *cf.* Rathke, **29**. p. 87) to a single representative.

The terminal portion of the intestine in these fishes exhibits, as a general rule, an increase in calibre and distensibility over the rest, and at its point of differentiation there is usually present, in the adult, a well-defined valve (*cf.* Cuvier and Valenciennes, 4. p. 502) which clearly suggests the ileo-colic valve * of the higher Vertebrata.

The cæcal diverticulum, when present, overhangs this; and, although it never attains a considerable development, comparison with the other Ichthyopsida and the Reptilia leaves little room for doubting that it represents those derivatives of the gut which I have attempted to homologize in the preceding part of this paper. Having accumulated some notes upon the same in those genera before referred to which I have been able to examine, I here tender them for what they may be worth.

Trigla gurnardus. The ileo-colic valve is, in the adult, exceedingly well marked—so much so that it reduces the ileo-colic aperture to a minute perforation. The large intestine exhibits but a small increase in calibre as compared with the ileum; and there is consequently no trace, in the adult of this species, of an overhanging lobe or cæcum. I have observed, however, in a young specimen of 16½ centim. in length, a perceptible enlargement of the antero-dorsal extremity of this viscus, suggestive of the small cæcum of the Frog (*dv'*, fig. 3).

Cyclopterus lumpus. I am unable to confirm Rathke's statement concerning the presence of a cæcum in the adult of this species. The ileum enters the large intestine antero-ventrally (*cf.* Pl. II. fig. 17); the increase in calibre of the latter is well marked, and there is developed a highly efficient and flap-like ileo-colic valve. In the young animal, however, the conditions may be otherwise. I have examined two juveniles of this species †. The intestine appeared, in them, when looked at externally, to be destitute of a cæcum; when opened from the side, care being taken to avoid unnecessary displacement of the gut, the ileo-colic aperture was seen to be situated ventrally (fig. 17) and, in one of the two, comparatively far back. The ileo-colic valve

* It is very regrettable that this should be so frequently referred to, alike in original monographs and text-books of both anatomy and physiology, as the ileo-cæcal valve. Huxley has long since shown this term to be expressive of an error of observation in fundamentals (see Parker, P. Z. S. 1881, p. 625).

† Thanks to Prof. W. McIntosh, F.R.S., and my pupil Mr. E. W. L. Holt.

was represented by the tumid and inpushed base of the ileum, and from that it would appear to be, in all probability, derived. A line drawn vertically through the same (α—β of fig. 17, Pl. II.) passes behind an overhanging lobe of the large intestine—the cæcum (*dv'*). Curiously enough no such enlargement was to be seen in the second specimen; and the question naturally arises whether, after all, the differences between it and the other one may not have been due either to over-distension in the one case or over-contraction in the other. Further investigation can alone settle this matter; but it is interesting to point out that a precisely similar difficulty arises in relation to the alleged discovery, by Perrault*, of a cæcum in *Salamandra.*

Box vulgaris†. Cuvier and Valenciennes state of the intestine of this fish (**5.** p. 354) "arrivé dans la partie moyenne du ventre, il se dilate subitement et donne même une sorte du petit cæcum très-court à l'origine du rectum, qui se rétrécit bientôt et se rend à l'anus." This "cæcum" is, in this fish, unmistakable and well marked externally, and it lies to the left side (*dv'*, fig. 16). The stomach of this species is remarkable for the characters of its pyloric sac; that (*st''*, fig. 17) instead of being short and swollen, as is so generally the case among the Teleostei, is elongated and tubular. The cardiac gastric sac (*st'*.) is constricted at its middle and, with the base of the stomach, prolonged back into a crescentric diverticulum, into the concave border of which the head of the large intestine (*i.l.*) is received. On dissection of this fish from the side, the air-bladder is seen to be greatly enlarged; its posterior moiety tapers off much less suddenly than usual, and it, together with the greatly developed fat masses, obliterates for the most part the posterior two thirds of the cœlom. The cæcum, when examined with sufficient care, is seen to be situated dorso-laterally rather than laterally, and to occupy a position which points very strongly to the conclusion that it and the immediately related intestinal wall have undergone a displacement (in mutual adaptation to the surrounding organs) of a precisely similar nature to that affecting

* 'Mém. pour servir à l'hist. nat. des Animaux,' 3e partie, pl. 16, p. 481. (*Cf.* Milne-Edwards, Leçons s. l. Phys. et l'Anat. Comp. t. vi. p. 354.)

† I have to thank Dr. Günther, F.R.S., for a well-preserved specimen of this fish.

Cuvier and Valenciennes describe (**5.** p. 364) two cæca in *B. salpa.* I regret having been unable to procure an individual of this species.

the cæcum coli and appendix digitiformis of certain other Vertebrata (cf. *ante*, p. 396).

An ileo-colic valve is not differentiated.

It may be urged, against my belief in an homology between the above-described cæcum of the Teleostei and the cæcum coli of the higher Vertebrata, that the intestinal (*ileo-colic*) valve of the former appears to lie within the area of the so-called spiral valve of the Clupeoid *Chirocentrus* * and of the annulations of the intestinal mucous membrane in the Salmonidæ and other Teleostei (*cf.* Rathke, 29. pp. 62 *et seq.*). In *Chirocentrus* the prevalvular gut is short, and the intestine passes to the exterior without convolution. In the Salmonidæ the prevalvular gut is elongated and bent upon itself. Huxley, writing on this subject, says (*l. c.* p. 138):—"I am inclined to believe that the circular valve which separates the colon from the rectum in the Smelt is merely a last remainder of the spiral valve" (of the Ganoids and *Chirocentrus*). This valve occupies in the Smelt precisely the position of that which I have been led to compare (*ante*, p. 401), in other Teleostei alluded to, with the ileo-colic valve of the higher Vertebrata. Assuming, for the moment, that the annulated segment of the gut in the Trout and Salmon and the post-valvular portion in the Smelt are homologous, and representative of the large intestine of other Teleostei, examination of these in the order named might, at first sight, appear to show evidence of a gradual diminution in length in passing from the former to the latter. Rathke, six-and-thirty years ago, drew attention (*l. c.*) to the fact that in the Salmonidæ the annular folds alluded to are susceptible to great variation and difference with age. He, nevertheless, regarded them as restricted to the rectum. If the lining membrane of the Smelt's intestine be carefully examined it will be found to be produced into a very obvious series of crenulated annular folds, throughout the area occupied by the more definite series of the Salmon and Trout. The valve to which Huxley alludes, and which I regard as the probable homologue of the ileo-colic valve, lies within an interrupted area in this series—in the Salmon and Trout it is absent.

* Cuvier and Valenciennes, 'Hist. nat. des Poissons,' t. xix. p. 151, pl. 565. *Cf.* Huxley, P. Z. S. 1883, p. 138.

In view of the constancy of this valve, and of its relationships previously referred to, as compared with the variability of the annular folds, I am decidedly of opinion that, if the homology between the latter in the Smelt and Salmonidæ named be admitted, that segment of the gut which bears them must represent something more than the large intestine, as I have defined it—whereupon the post-valvular portion of the Smelt's intestine and the annulated segment of that of the Salmon and Trout would appear to be non-homologous. In face of these facts and considerations, the conditions in *Chirocentrus* become most perplexing. On comparison with the Elasmobranchs, its valved intestine might represent that which I regard, in them, as the small intestine—in which case the large intestine would appear to be absent and the gut, taken as a whole, to be less modified than that of even the Ganoids. On the other hand, comparison with the Salmon would appear to show (if the annulated segment of the gut of that fish should have the value which Rathke attached to it) that the valved gut in *Chirocentrus* might represent the large intestine as defined by myself.

That, in seeking to establish homologies, too much importance must not be attached to the mere presence or absence of an intestinal spiral valve in the Teleostei, is clear, from the differentiation of a like structure in the œsophagus of *Chanos* *, and of an essentially similar one in that of the *Marsipobranchii* †. I have attempted to show (*ante*, p. 395) that the large intestine is, in the Plagiostomes, well marked though short. The appendix digitiformis is smallest where situated furthest back; and in the young of those forms which I have been able to examine (*Scyllium*, *Mustelus*, *Acanthias*, *Heptanchus*) it is situated further forwards than in the adult. We have thus a suggestion of reduction proportionate to a shortening up of that which I regard as the large intestine; a further extension of such a process (be it at work) would give us the condition met with in the Ganoids and *Chirocentrus* (supposing the resemblances between the intestine of this fish and that of the Plagiostomes to

* Cuvier and Valenciennes (6. p. 185).

† Günther describes this ('Introduction to the Study of Fishes,' p. 128) as consisting of "numerous longitudinal folds." They are oblique and more nearly ovoidal. Parker has shown (26) that the particular characters in the "pitch" and mode of disposition of such "valves" are matters of no morphological significance (*cf.* his pl. 10. figs. 1 and 4, and pl. 11. figs. 6 and 8).

be indicative of homological relationship); the converse process would tend towards that of the majority of the Teleostei and of the higher Ichthyopsida *.

If this comparison should stand the test of future investigation, the folds of the intestinal mucous membrane in *Chirocentrus* and the *Salmonidæ* will be non-homologous. To deny that the large intestine of the majority of the Teleostei, as herein defined, represents that of the higher Vertebrata, would be, in the present state of our knowledge, to imply that the comparative method upon which our fundamental conceptions in morphology are based is untrustworthy.

The large intestine remains comparatively short throughout the Ichthyopsida, the Sauropsida, and the lower Mammalia; it is not until an ascending term in the Mammalian series is reached that it shows signs of clear differentiation into the colon and rectum so well known among the higher representatives of the same. That the cæcum coli, however, not only

* Owen and Hyrtl have long ago described in *Protopterus* a median diverticulum of the antero-dorsal wall of the cloaca, believed by them to represent the urinary bladder. Parker has recently overthrown their interpretation, and proposed (**28.** p. 14) to term the organ the *cæcum cloacæ*—comparing it with the Plagiostome's appendix digitiformis; his proposal receives a special interest from the fact that Günther has described the appendix digiti formis of *Chlamydoselache* (**11.** p. 3) as "a globular glandular body of the size of a large pea," which "lies dorsad of the cloaca, into which it discharges its secretion by a short duct"—a condition unknown in any other Plagiostome. Garman, on the other hand, speaks of it (**10.** p. 20) as "a cæcal pouch behind the (spiral) valve."

I am indebted to my friend Mr. G. A. Boulenger for the opportunity of examining the parts in question in this Japanese Shark. Dr. Günther does not state exactly in what sense he uses the term "cloaca"; if by this we are to understand that portion of the gut situated posteriorly to the anal and urino-genital orifices, Garman's description in perfectly correct. The duct of the processus digitiformis is short and, like that of other Selachii, forwardly directed; it opens but a short distance in front of the anus and much nearer the same than in any other Plagiostome which I have examined. The whole condition of the parts related favours the belief in the shortening up of the large intestine arrived at above, and that is strengthened by the insignificant size of the cloaca, which would appear to have been involved in the process.

Parker's cæcum cloacæ opens directly backwards by a wide aperture; it is present in both sexes, and it might conceivably represent the conduit at least of the Batoid processus digitiformis (*dv'*, fig. 1) in a much modified form. It appears to me, however, to most nearly recall that diverticulum in the female Chimæroid which Hyrtl termed (Sitzb. Wien. Akad. Bd. xi. 1853, pp. 1085–86) the "*vesicula seminalis*," and the absence of a corresponding vesicle in

exists in the class Pisces, but is present, in a low order of the same, in that which may probably prove to be its original form, I fully believe. Moreover, the facts go to show that in certain Teleostei (*Trigla*, *Cyclopterus*) the small cæcum may possibly disappear as the intestine increases in convolution; and it therefore becomes a matter of interest to inquire whether the first-named structure may not be more generally represented in at least the young of that order.

V. *In Conclusion.*

The deductions which I have drawn are based chiefly upon facts arising out of a comparison of leading blood-vessels; and I fully anticipate that it will be doubted whether these are to be trusted, to the extent claimed, as guides to homology. Precedent might be cited to suggest that they are not—the recent investigations of Boas (3) and Zimmermann (34) into the aortic arches, of Hochstetter (12) into the post-caval and azygos veins, and of Parker (27) into the lateral epigastric veins, justify the belief that they are. Objections may be here raised on the ground that the great vessels just named do not undergo variation such as do those of the intestinal series upon which I am relying. Against this there must be set the fact (which, so far as I can ascertain, has escaped notice) that the fifth aortic arch, which Boas has so successfully shown (3 *et op. cit.*) to be present between the aorta and the pulmonary artery of the Urodeles, may be (*Salamandra*) either absent on one or both sides or, when present, variable between the condition of a widely open tube and that of a vestigial cord of insignificant proportions

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the male Chimæroid is an obstacle in the way of a belief in its homology with the processus digitiformis of the Plagiostome.

Günther has described (Phil. Trans. 1871, part ii. pp. 546–47) the genital ducts of *Ceratodus* as opening, together with the ureters, into a "urinal cloaca;" and the latter would appear, at first sight, to answer to the cæcum cloacæ of *Protopterus*. I have not been able to examine the male *Ceratodus*, but I think it tolerably certain, on examination of the female, that Parker's "cæcum cloacæ" and Günther's "urinal cloaca" will prove to be distinct in origin, and that the latter will be found to represent that portion of the Elasmobranch's cloaca which I herein term (*ante*, p. 383) the "oviducal recess" (*cl'''*, Pl. I. fig. 1). Indeed this has been, in a sense, already anticipated by Günther, who refers to the sac on one page (*l. c.* p. 546) as "a dorsal diverticle of the rectum," and on the next (p. 547), in somewhat contradictory terms, as "the cloacal dilatation."

There is indicated in the concluding sentence of the preceding section one of the next steps in this inquiry; others lead to a further investigation into the histology and development of the appendix digitiformis, and to a study of the comparative histology of those structures to which the terms "cæcum coli" and "appendix vermiformis" have been applied. Upon these I propose to enter on a future occasion.

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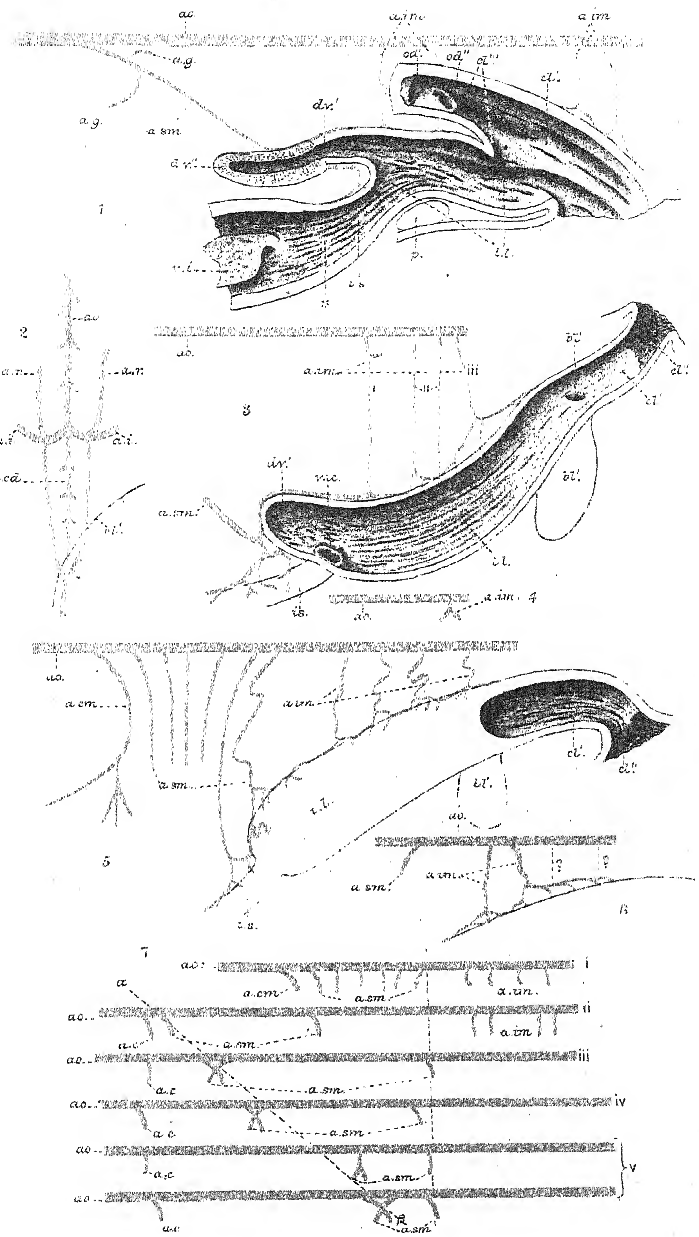
VII. EXPLANATION OF THE PLATES.

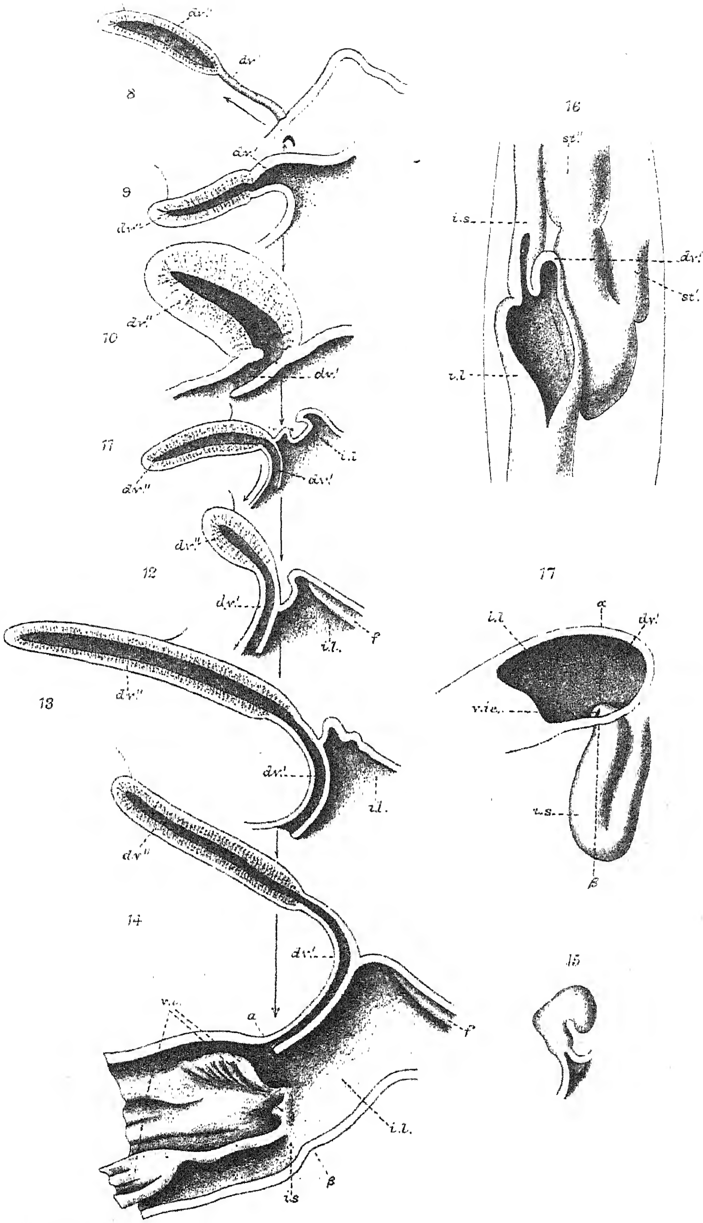
Figs. 1, 3, 4, 5, and 6, and figs. 7, i. to v. are drawn to the same scale in order to facilitate comparison; the dorsal aorta (*ao.*) is, in all but 7, iii. iv. & v., delineated up to the point of origin of the iliac arteries. Only vessels of the precaudal median-intestinal series are indicated; all others are intentionally omitted.



G.B.H. del. ad nat. M. P. Parker lith.

West, Newman imp.

Intestinal Canal & Arteries of Ichthyopsida.



G.B.H. del. ad nat. M.P. Parker lith.

West, Newman imp.

Intestinal Canal & Arteries of Ichthyopsida.

Figs. 8 to 14 are drawn to the same natural size, proportionate to the transverse diameter of the base of the valved intestine.

PLATE I.

Fig. 1. *Raia clavata*, adult ♀. The cloaca and terminal portion of the intestinal canal, with related arteries, dissected from the side, after injection with French blue. $\frac{3}{4}$ nat. size.

2. *R. clavata.* To show the origin and relationships of the paired cloacal arteries. $\frac{3}{4}$ nat. size.

3. *Rana temporaria*, ♀. A similar dissection to fig. 1. The arteries represented are a combination of those observed for four individuals referred to in the text. × 2.

4. *Rana temporaria*, ♂. To show the base of the inferior mesenteric artery, in an individual specimen described in the text. × 2.

5. *Salamandra maculosa*, ♀. Comparison dissection to figs. 1 & 3. × 2.

6. *Salamandra maculosa*, ♂, showing two inferior mesenteric trunks. × 2.

7. To represent the dorsal aorta and the origin of the cœliac and mesenteric arteries in relation to the same in—i. *Salamandra maculosa*; ii. *Raia clavata*; iii. *Mustelus antarcticus* (after Parker [27]); iv. *Scyllium canicula*; v. *Acanthias vulgaris.*

PLATE II.

Fig. 8. The appendix digitiformis, with its related parts, in median longitudinal section, in *Zygæna malleus.*

9. The same, in *Raia clavata.*

10. The same, in *Læmargus borealis.*

11. The same, in *Scyllium canicula.*

12. The same, in *Cestracion philippi.*

13. The same, in *Acanthias vulgaris.*

14. The same, together with a portion of the valved intestine, in *Notidanus (Heptanchus) cinereus.*

15. The same, in *Rhina squatina*; external view. Nat. size.

16. The cæcum and adjacent portions of the alimentary viscera, in *Box vulgaris.* × 2.

17. The head of the large intestine of *Cyclopterus lumpus* (juv.), as seen from the right side. × 2.

Reference letters.

a.c. Cœliac artery.
a.cd. Caudal artery.
a.cm. Cœliaco-mesenteric artery.
a.g. Genital (ovarian) arteries.
a.i. Iliac arteries.
a.im. Inferior mesenteric arteries.
ao. Dorsal aorta.

a.r. Posterior renal arteries.
bl'. Allantoic bladder.
bl''. Orifice of the same.
cl'. Cloaca.
cl''. Epidermal portion of the same.
cl'''. Oviducal recess of the same.
dv'. Cæcum coli (or its probable homologue).
dv''. Appendix digitiformis.
f. Longitudinal fold in roof of large intestine.
i.l. Large intestine.
i.s. Small intestine.
od'. Left oviduct.
od''. Right oviduct.
p. Pelvic girdle.
st'. Stomach, cardiac sac.
st''. Stomach, pyloric sac.
v.i. Intestinal (spiral) valve.
v.ic. Ileo-colic valve.

On the Tongues of the British Hymenoptera Anthophila. By Edward Saunders, F.L.S., F.E.S.

[Read 17th April, 1890.]

(Plates III.–X.)

In Vol. XVII. of this Journal Mr. Travers J. Briant has ably described the tongue of *Apis mellifica* and its anatomy, and I purpose in this paper to give descriptions of this organ in other British genera of Hymenoptera Anthophila, accompanied with figures carefully drawn from slides prepared by Mr. Enock, whose skill in this direction is well known. At the present time I know of no figures that, in any way, give an idea of the beauty and complexity of structure which characterize the different genera. The number and proportionate lengths of the joints of the palpi and the general form of the so-called lingua have been the only characters usually selected for generic determination, whereas the form of the *lora, submentum, scales of the maxillæ,* and *paraglossæ* afford additional characters quite as important, as will be seen by the accompanying Plates. As a general result from the study of these organs, it would appear that there is a gradual modification of form from the short bifid

tongue of the *Obtusilingues* to the long filiform one of the higher *Apidæ*; that the lora or Λ-shaped hinge by which the mentum and lingua can be projected is more developed in the higher genera, and accordingly allows of greater play for those organs; that the basal joints of the labial palpi are flattened and sheath-like in the higher genera, so as to form a protection for the base of the tongue; and that the paraglossæ also tend, in these genera, to take a sheath-like form. In the early genera the lora can scarcely be said to exist definitely at all, the membrane between the cardines being merely chitinized towards the apex and raised so as to form an arch which acts as a hinge; in *Halictus*, *Sphecodes*, &c. even this is absent (see descriptions of those genera). There appears to be a regular progression in development, but this progression is arrested here and there by certain genera which seem to defy one to find a proper place for them. Such a genus is *Rophites*. It has the labial palpi of the higher Apidæ, paraglossæ quite unlike in form to those of any other genus, no definite lora, in this respect resembling *Sphecodes* and *Halictus*, to which latter genus it greatly assimilates in general appearance, and a tongue as long as that of any of the Apidæ. *Panurgus*, again, is quite aberrant and difficult to localize in any arrangement, as, apart from its lingual peculiarities, its genital armature is quite unlike that of any of the genera that could be considered allied to it. These special features, however, will be described more fully under each genus.

The cibarial apparatus in all the genera is arranged on the same general plan as in *Apis*, but varies very considerably in its details, both as to the shape and the relative proportions of its component parts, and it is on the characters afforded by some of these variations that many of the different genera have been established. I propose here to give a general description of the apparatus, leaving the special features of each genus to be considered further on.

At the back of the head, behind the face, between the occipital foramen and the mandibles, is a deep wide groove, with abruptly truncate sides, which lie nearly parallel to each other; it is determined somewhat semicircularly at its basal or occipital end, *i.e.* that nearest the juncture of the head and thorax, but is open at its apical end, except when closed by the mandibles folding across it. The floor of the groove is the posterior surface of the actual wall of the face. It is in this groove that the cibarial

apparatus lies folded when at rest, and I shall here refer to it as the oral groove. By gently pulling the apex of the tongue, the whole apparatus may be gradually unfolded, and it will then be seen that there is a membrane investing the entire base of the apparatus and completely covering the oral groove; this is best seen when the tongue is fully extended. On dissecting the head it appears that this membrane is attached to the back of the clypeus on each side, whence it arches downwards and forms what has usually been termed the hypopharynx, between which and the epipharynx is a very small opening, and it is through this opening only that there is communication with the gula, except through the actual lingua itself. The cibarial apparatus may, in fact, be compared to a funnel-shaped bag strengthened by various sclerites above and below (which also aid in its folding up), and prolonged at its apex into the semitubular mentum and lingua. The arrangement of the various sclerites is as follows. I shall commence with those on the underside :—

On the anterior edge (*i. e.* that lying furthest from the back of the head) of each of the truncatures that bound the oral groove is an emargination, into which articulates an elongate joint, these joints are called the *cardines*; each *cardo* is considerably widened at its apical end, and produced into two unequal processes. On these widened portions swing the *lora*, and from them depend the *maxillæ*, each of which consists of a sheath-like basal portion and a blade-like apex, between which on the external side the *maxillary palpus* is inserted. The *lora* are two narrow joints united so as to form a Λ-shaped body, from the angle of which is suspended the mentum, &c.; these can swing over on their feet which rest on the apices of the *cardines*, and by this motion the tongue can be projected for twice the length of the Λ. They vary very much in their length, and in some of the genera of the short-tongued bees are scarcely developed; but in only four British genera are they actually wanting, viz. in *Halictus* and *Sphecodes*, and in *Dufourea* and *Rophites*, in which there appear to be no traces of them, and, in fact, there appears to be nothing to correspond to them in their office of lengthening the tongue; the membrane covering the space between the cardines, which in the other genera is simple, is here chitinized towards its centre into two straps, which are united to the submentum at their apices. From the angle of the *lora* hangs the *submentum*, which varies considerably in shape; although always more or less

widened towards the apex, it is sometimes quite short and triangular, at others many times longer than wide. It also varies in substance, in some genera being clear and hyaline, in others dark and opaque; it is short and more or less hyaline in the early genera of the short-tongued bees, and elongate in most of the true Apidæ, and in the somewhat aberrant short-tongued genera, such as *Macropis*, *Cilissa*, and *Dasypoda*; whereas in *Panurgus* again the short hyaline form shows itself, and in *Bombus*, *Psithyrus*, and *Apis*, although not hyaline, it is short and triangular. Beyond the submentum comes the mentum itself, which is brown, chitinous, and semitubular, and forms a supporting sheath for some of the softer parts of the apparatus to lie in; above, it is sometimes strengthened by elongate sclerites, as in *Megachile*, *Osmia*, &c.; it varies very little in form, being usually slightly narrowed and rounded at the base, truncate or produced into one or more lobes at the apex beneath; from either side of the apex extends one of the labial palpi, and from between them the so-called lingua. Near the base of the mentum on each side is attached a sclerite, which passes upwards between the maxillæ and thence under the labrum, where it is abruptly angulated, its apex lying just at the side of the anterior edge of the oral groove, close to the emargination into which the cardo articulates. These sclerites hold the upper part of the membranous bag expanded anteriorly when the tongue is extended. Huxley has called them "the sclerites of the hypopharynx." They are united to the maxillæ by the investing membrane, which just at the point of union on either side gives rise to a sort of scale which is often fringed with bristle-like hairs; these scales, which appear to exist in all our genera, although obsolete in *Apis*, seem to have been scarcely noticed by authors; they are very much developed in *Anthophora* and also in *Megachile*, *Osmia*, and their allies. Beyond the basal ends of these sclerites, and with their anterior extremities lying between them, are two others, which can only be seen when the clypeus and face and the top of the œsophagus are removed; they are what Huxley has called the "sclerites in the wall of the œsophagus." They converge posteriorly, and are somewhat hamate at their posterior ends; the membrane which lies between these forms the floor of the mouth. Anteriorly, this membrane is chitinized, and forms what has been called the hypopharyngeal plate; on this chitinized portion, which is slightly concave, may be

observed various papillæ, which at first sight look like punctures, and on each side is a nipple-shaped opening, through which the secretion from the salivary duct can pass. Beyond this chitinized plate is the opening into the œsophagus. We will now proceed to consider the lingua, which, as was stated above, extends beyond the mentum between the two labial palpi. The base of the lingua is ensheathed by the two paraglossæ; these vary very much in form: as may be seen by a reference to the figures of the various genera, a chitinous band extends across the base of the lingua in front, and terminates on each side below in a pointed process. The lingua varies much in form, from the short broad bifid organ of *Colletes* to the long narrow one of *Anthophora*. In all the genera the surface is traversed by fine ridges set with bristly hairs. The base of the lingua in the higher Apidæ is really ensheathed by three sets of appendages: 1st the maxillæ, 2nd the labial palpi, 3rd the paraglossæ; but in the short-tongued bees the labial palpi have no sheathing properties, all their joints being cylindrical.

I do not here propose to give any description of the functions &c. of the tongue, as these have been described by Mr. Bryant, and I have confined myself to describing the position and general form of its skeleton. For clearness' sake I recapitulate the sclerites thus:—

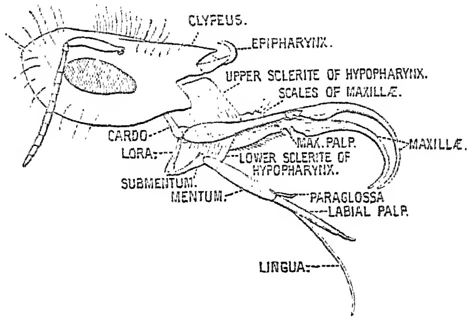
a, a. *Cardines* articulated into an emargination in oral groove.
b, b. *Lora* swinging on the dilated ends of the cardines.
c, c. *Maxillæ* articulated to ends of cardines.
c^a, c^a. *Scales of maxillæ* exserted from membrane at base of maxillæ.
c^b, c^b. *Maxillary palpi* inserted between base and blade of maxillæ.
d. *Submentum* attached to apex of lora.
e. *Mentum* attached to apex of submentum.
e^a, e^a. *Labial palpi* attached to apex of mentum laterally.
f. *Lingua* attached to apex of mentum centrally.
f^a, f^a. *Paraglossæ* ensheathing the base of the lingua.
f^b. *Scleritic ring* forming a transverse band at the base of the lingua.
g, g. *Sclerites of hypopharynx* originating on the margin of the oral groove, passing between maxillæ and uniting with mentum near its base.

h, h. *Epipharynx* projecting under the labrum.

i. *Labrum* attached to the clypeus.

j, j. *Sclerites in the wall of the œsophagus* forming the floor of the mouth.

It only remains now for me to state that it is to the beautiful preparations of Mr. Enock that all the merit of this paper is due, and to thank him cordially for doing the work so well.



Lateral diagrammatic view of head of *Bombus*: mandibles and labrum removed.

Colletes, *Latr. Hist. Nat.* iii. p. 372. (Pl. III. figs. 1, 2.)

Labrum transverse, broadly and bluntly angulated in front, densely fringed with long bristly hairs. Epipharynx visible beyond the hairs of the labrum, somewhat rounded in front, its extreme apex pointed. Sclerites of the hypopharynx much curved and twisted; the scales at the membranous base of the maxillæ represented by two or three strong bristly hairs. The maxillæ are rounded at the apex, and reach just to the base of the lingua, round the apex they are fringed with a row of short curved bristly hairs, and longer hairs, which show traces of branching, below them; their inner edge is very thin and membranous: their surface is impressed with irregularly disposed punctures; the reflexed under margin of the maxillæ bears a row of long curved bristles, these in a strong back light can be seen through the substance of the maxillæ from above. Maxillary palpi 6-jointed. Paraglossæ concave above, wide at the base, remotely punctured, their anterior margins with a row of deep punctures, from each of which springs a curved bristle. The lingua is deeply cleft at the apex, its base is convex and in the form of an equilateral triangle, the base of the lingua being the apex of the

triangle; the base of the triangle or anterior margin is widely emarginate; projecting beyond this triangle is the apical portion of the lingua, which almost appears to be produced from under the basal canopy, *i. e.* it is on a lower level than it; it is slightly rounded at the sides and deeply and angularly cleft in the middle right into its base; the canopy and the surface of both the basal and apical portions are exceedingly finely ridged transversely, and set with very short bristles, and the apical portion is also covered and fringed round its edges with very fine soft long hairs. Mentum beneath about $2\frac{1}{2}$ times as long as wide; labial palpi 4-jointed, the basal joint much wider and longer than the others. Submentum hyaline, short, and subtriangular. Lora short and not well-defined, as they gradually merge into the investing membrane which covers the space between the cardines, this membrane becoming gradually darker in colour, and scleritic as it approaches the lora.

PROSOPIS, *Fabr. Syst. Piez.* p. 293. (Pl. III. figs. 3–5.)

Labrum transverse, very slightly angulated in front, its anterior margin armed with a row of very strong testaceous spine-like hairs. Epipharynx extending beyond the spines of the labrum and somewhat pointed. Sclerites of the hypopharynx strongly developed, slightly curved above the maxillæ. Scales at the base of the maxillæ well developed, elongate, and fringed with long hairs; blades of the maxillæ short, somewhat sinuate on the external margin, their inner edge membranous, fringed with thick bristles round the apex, which is widely rounded. Surface impressed with a few irregularly disposed punctures. The reflexed under margin with a series of sharp bristles. Maxillary palpi 6-jointed. Paraglossæ elongate, about twice and a half as long as wide, not much narrowed to the apex, the apex fringed densely with fine hairs. Lingua very short and wide, its basal portion in the form of an obtuse-angled triangle, very finely ridged transversely and set with bristles, until near the apex, where the ridges and hairs stop, and are replaced by a wide band, which under a $\frac{1}{4}$-inch power is apparently glabrous, and its surface finely shagreened or rugose; the anterior margin of the basal portion or canopy is almost straight; the apical portion projects from beneath the canopy, much as in *Colletes*, but is very short and not deeply cleft, but only widely and

shallowly emarginate anteriorly; its surface is finely ridged and clothed with long irregularly curved hairs. Beneath, the mentum is a good deal widened anteriorly, about twice and a half as long as wide; it has a strong ridge running nearly parallel to its external margin; labial palpi 4-jointed. The submentum is short and hyaline. Lora wanting: what acts as such is the thickened apical portion of the membrane which covers the space between the cardines; this thickened portion is convex, and so forms an arch at its apex, to the centre of which the submentum is attached; it is therefore evident that the play of the lora affords very little power of extension to the tongues of the species of this genus.

SPHECODES, *Latr. Hist. Nat.* xiii. p. 368. (Pl. III. figs. 6–8.)

Labrum at the base broader than long, its sides somewhat rounded and converging towards the apex; apical margin emarginate, sides and apical margin, except just the centre of the latter, bearing a row of thick spine-like bristles, these are situated just within the actual margin; epipharynx subtriangular. Sclerites of the hypopharynx double on each side, the outer one terminating below the apical margin of the labrum, and uniting, or nearly uniting, at its base with another sclerite, which passes diagonally down the side of the expanded membrane which invests the base of the cibarial apparatus; this membranous bag is peculiarly developed in this genus and *Halictus*, and its surface covered with transverse rows of very short bristly hairs; near the juncture of the two sclerites above mentioned, the membrane gives rise to two or three long upright bristles, which appear to me to represent the scales at the base of the maxillæ, which are so much more developed in the other genera. The maxillæ are rounded at the apex, their inner edge very finely and transparently membranous, the thicker portion of the maxillæ remotely punctured; palpi 6-jointed. Paraglossæ membranous and transparent, somewhat falcate. Lingua convex above, longer than wide, its sides rounded to the apex, which is somewhat bluntly pointed, its surface finely ridged, the ridges bearing rows of short bristles. Beneath, the mentum is not quite three times as long as wide; the labial palpi are 4-jointed; the submentum is very short and transparent, in fact it is not easy to trace its shape at all. The lora, so far as I can make out, do not exist at all, either in this genus or in *Halictus*. The cardines are very

long, and the membrane uniting them bears down the middle two darker chitinized straps, each of which narrows towards its apex, which is abruptly turned inwards, terminating just above the base of the submentum, so that there is no hinge by which the mentum &c. can be thrown forwards: possibly the elasticity of the membrane may be such that the bee by an extra effort can stretch it, but in any case the apparatus employed seems to be strangely different in these two genera from what it is in their allies.

HALICTUS, *Latr. Hist. Nat.* xiii. p. 364. (Pl. III. figs. 9–11.)

Almost exactly similar to *Sphecodes* in its oral arrangements, but with the labrum more transverse; the paraglossæ more developed and produced into two elongate parallel-sided processes densely fringed with branched hairs; lingua longer, its sides rounded nearly to the apex, then slightly sinuate, the hairs of the surface of the lingua also longer than in *Sphecodes*, and distinctly branched towards the apex, otherwise the description of that genus will apply in all essential points to this.

ANDRENA, *Fabr. Syst. Ent.* p. 376. (Pl. IV. figs. 1–3.)

Labrum transverse, fringed with long bristly hairs; epipharynx triangular. Scales at the base of the maxillæ well developed, elongate oval, bearing several long bristles, some of which are more or less branched. Maxillæ extending to about the widest part of the lingua, somewhat rounded at their apices and fringed with hairs, their inner edge narrowly membranous, and their reflexed under margin with a row of closely-set bristles observable through the transparent substance of the maxilla; palpi 6-jointed. Paraglossæ transparent, truncate at the base, which is margined with a narrow band of darker chitine, impressed with a row of punctures; apex of each produced into a lobe transversely ridged and set with short bristles like the lingua. Lingua a little more than twice as long as wide, finely ridged transversely, and clothed with short hairs, those at the apex longer. Beneath, with the mentum elongate, four times as long as wide at the apex; submentum elongate, hyaline. Lora represented by the apical triangular arch formed by the convex scleritic apical portion of the membrane investing the space between the cardines; in this character *Andrena* seems to approach closely to *Colletes* and *Prosopis*, but the ends of the

arch appear to rest on the apices of the cardines, and therefore the apparatus approaches more nearly in its arrangement to the lora of the higher Apidæ.

CILISSA, *Leach, Ed. Enc.* ix. p. 155. (Pl. IV. figs. 4–6.)

Labrum transverse; epipharynx triangular. Scales of the maxillæ dark and suboval, deeply foveated, set with a few bristly hairs; sclerites of the hypopharynx visible on each side of the labrum. Maxillary palpi 6-jointed; blades of the maxillæ rather short, wide at the base, gradually narrowing into a sharply-pointed apex, their surface punctured. Paraglossæ with a broad basal sheath, and an apical process fringed with long hairs. Lingua wide at the base, produced into a sharply-pointed apex, its sides slightly concave, clothed with hairs at the base, pointing towards the apex; at the apex with some of the hairs erect, giving it somewhat the appearance of a bottle-brush; each of these hairs has at the apex two or three branches. Mentum beneath three times as long as wide; labial palpi 4-jointed, first joint as long as the second and third together, apical joint narrower than the others, longer than the third. Submentum elongate, its apex hyaline; lora very strongly developed and thick. Cardines wide and straight.

MACROPIS, *Panz. Faun. Germ.* Hft. 107, p. 16.
(Pl. IV. figs. 7–9.)

Labrum transverse, slightly rounded in front, densely fringed with long hairs intermixed with thicker spine-like bristles; epipharynx sharply angular in front. Scales at the base of the maxillæ curved inwards, subreniform. Maxillæ with the blades sinuate exteriorly, fringed with long hairs at their apex, which is rounded; internal membranous margin very narrow; maxillary palpi 6-jointed. Paraglossæ with their basal portions slightly longer than wide, rounded on its external margin, somewhat angular on its internal, its extreme base bearing a few bristly hairs springing from deep holes; its apical portion elongate, pointed, towards the extremity clothed with bristly hairs. Lingua elongate, subtriangular; its sides slightly rounded, its apex narrowly produced and clothed with long projecting hairs—its base clear and hyaline, the rest finely ridged transversely and set with short hairs. Mentum beneath gradually widening to the apex, about $3\frac{1}{2}$ times as long as wide; labial palpi 4-jointed,

the basal joint thickest and longest. Submentum widened and hyaline at the apex, narrow and darkly chitinous at the base. Lora distinct, not very long, forming an obtuse angle at their point of juncture.

DASYPODA, *Latr. Hist. Nat.* iii. p. 372. (Pl. V. figs. 1–3.)

Labrum transverse, its anterior edge slightly rounded, densely fringed with long golden hairs, all of which appear to be more or less plumose or spinose. Epipharynx slightly pointed at the apex. Scales at the base of the maxillæ very elongate, oval, set with long porrect, slightly spinose hairs. Maxillæ with the blades very long, gradually rounded on their outer margin, straight on the inner; apex pointed; inner margin almost destitute of any membrane, except just opposite the insertion of the maxillary palpi; these latter are 6-jointed. Paraglossæ narrowed at the base, their inner basal margin rounded and bearing a row of stiff bristles, their outer basal margin concave; across the centre they are widened, from whence the outer apical margins converge in slightly rounded lines, and the inner apical margins diverge in nearly straight lines, and the apex is produced into a narrow, slightly pointed process. Lingua much more elongate than in any of the preceding genera; the transversely ridged portion four times as long as broad, gradually tapering to the apex, which, however, appears to be destitute of the ladle-shaped termination observable in the higher Apidæ. Beneath with the mentum about four times as long as wide, very little widened towards the apex. Submentum long, widened at the apex; labial palpi 4-jointed, the joints much swollen at the apex. Maxillæ clothed with very long spinose hairs; lora very strongly developed, forming an acute angle at their point of juncture.

PANURGUS, *Panz. Krit. Rev.* ii. p. 209. (Pl. V. figs. 4–6.)

Labrum transverse, widened in front, and slightly rounded on its anterior margin, fringed with long spinose hairs of rather unequal lengths. Epipharynx triangular. Scales at the base of the maxillæ ovate, set with strong upright bristles. Maxillæ with the basal portion fringed outwardly with a row of short erect bristly hairs; palpi 6-jointed; blades semilucent, pointed, gradually narrowed to the apex, with rather a wide membrane on their inner margins towards the base; surface apparently clothed

with exceedingly short hairs. Paraglossæ truncate at the base; the inner margin of the basal portion nearly straight, and almost uniting over the base of the lingua; apices produced into elongate pointed sheaths in shape something like the maxillæ. Lingua elongate, a little more than seven times as long as wide, finely ridged transversely, and with whorls of short bristly hairs; apex simple, with apical spoon-like lobe. Beneath, with the mentum widened towards the apex, about three times as long as its greatest width; labial palpi 4-jointed, the joints narrow and rounded, basal joint very long, longer than the 2nd and 3rd together. Submentum short, pear-shaped, and hyaline. Maxillæ with a tuft of long feathery hairs at the base; lora very feebly developed, formed, as in *Prosopis*, *Colletes*, &c., merely by the chitinized arch of the membrane investing the space between the cardines.

The feebly developed lora and subcylindrical labial palpi, associated with the long pointed paraglossæ and elongate lingua, characterize this genus as one of the most peculiar in our list, especially when it is remembered that in the ♂ genital armature it is also unlike all its congeners.

DUFOUREA, *Lep. Hist. Nat. des Ins.*, *Hym.* ii. p. 226.

Of this rare genus I have only one specimen with its tongue extended, which only shows some of the sclerites, but they evidently are arranged very much as in *Panurgus*. The maxillæ have some long hairs at the base; the lingua hardly extends beyond the apices of these organs. The maxillary palpi are 6-jointed; the labial 4-jointed, all of which are more or less cylindrical, as in the short-tongued genera; the basal joint is almost as long as the two following together. The submentum is short and subhyaline as in *Panurgus*, but there appears to be no thickening of the membrane between the cardines at its apex, as in that genus, and therefore nothing to correspond to the lora; the cardines themselves are very long and straight.

ROPHITES, *Spin. Ins. Lig.* ii. p. 9.

Labrum transverse. Epipharynx triangular, somewhat rounded at the apex. Maxillary palpi long, 6-jointed; blades of the maxillæ rather short, pointed, bearing on their surface some semierect hairs, internal margin membranous. Paraglossæ at the

base ensheathing the base of the lingua; their lateral portions produced into two elongate subfiliform processes, slightly widened and truncate at the apex. Lingua very long and rather thick, clothed with very long hairs. Mentum elongate, trilobate at the apex; labial palpi with the first 3 joints sheath-like, the 1st and 2nd subequal in length, 3rd very short, 4th divergent, cylindrical, about half as long as the 3rd. I have only dried specimens to work from, but the submentum is not recognizable, and the lora are apparently absent; in fact all the sclerites in this portion of the mechanism appear to be on the same plan as in *Sphecodes* and *Halictus*: through the dried membrane that lies between the cardines two elongate sclerites can be clearly discerned; these, I have little doubt, are analogous to the straps observed in the genera above mentioned; the cardines also are very long and thin, as in those genera. These points of resemblance in structure to *Halictus* are most interesting, as the facies of the insects themselves is so completely Halictiform. The shape of the labial palpi, on the other hand, is similar to those of the higher Apidæ, but the paraglossæ are unlike those of any other genus that I know.

NOMADA, *Fabr. Syst. Ent.* p. 388. (Pl. VI. figs. 1–3.)

Labrum transverse, anterior margin rounded, slightly produced in the centre. Epipharynx very long, its sides slightly sinuate, its apex bluntly pointed. At the base of the maxillæ are two suboval chitinized spots, which appear to represent the basal scales. Maxillæ dark outwardly, semilucent towards their inner margins; palpi very long, 6-jointed; blades pointed and fringed with hairs at the apex, inner margin broadly membranous. Paraglossæ wide, elongate oval at the base, slightly sinuate on their external margins, apex produced into an elongate spine-like process. Lingua elongate, nearly linear, nearly ten times as long as wide, finely ridged and whorled with bristles; apex with a spoon-shaped lobe, although this lobe seems to be retracted (at least in the specimen which I have examined) amongst the apical hairs. Beneath, with the mentum about four times as long as wide; labial palpi 4-jointed, the joints narrow and rounded, 1st joint longer than the other 3 together; submentum very long. Maxillæ with a few long plumose hairs at the base; lora well developed, but short; cardines very long.

This genus forms a curious transition between the Andrenidæ and Apidæ; it has many of the characteristics of the latter division, such as the long tongue, the acute paraglossæ, and the long basal joint of the labial palpi; on the other hand, however, it has the joints of the labial palpi subcylindrical, like the Andrenidæ, without any tendency to the flat or concave sheath-like form of the Apidæ, and its species are also parasitic on the Andrenidæ (with the exception of *N. sexfasciata*, which frequents the burrows of *Eucera*). These last two characteristics seem to me to outweigh the others; and notwithstanding the exhaustive remarks of M. J. Perez on this subject ('Contrib. à la Faune des Apiaires de France,' p. 152 *et seq.*), where he considers *Nomada* as allied to *Megachile*, I should feel inclined to treat it as a very abnormal genus of the Andrenidæ.

EPEOLUS, *Latr. Hist. Nat.* iii. p. 375. (Pl. VII. figs. 7, 8.)

Labrum transverse, its widest portion a little before the base, its sides thence converging towards the apical margin, which is slightly sinuate and bears a small tooth in the centre of the sinuation. Sclerites of the hypopharynx narrow and straight. Scales at the membranous base of the maxillæ represented by two little dark chitinous sclerites, which hardly project beyond the membrane. Maxillæ with their blades rounded at the apex, which bears round its edge a few extremely short hairs, very convex above and concave below, their inner edge slightly curved and rather narrowly membranous; palpi with one joint; under margin of the blades of the maxillæ produced so as nearly to ensheath the lingua &c. when closed. Paraglossæ wide and parallel-sided at the base, shaped something like razor-blades, their cutting-edge inwards; their outer margins thickened and produced at the apex into a long, slightly curved filiform process, extending to about the apex of the 1st joint of the labial palpi. Lingua very long, clothed with rather long hairs; mentum beneath five times at least as long as wide, subparallel-sided; labial palpi with the 1st and 2nd joints sheath-like, 1st once and a third as long as the 2nd, apex of the 2nd with a fringe of long hairs, 3rd and 4th joints cylindrical, 4th shorter than the 3rd; submentum elongate, widened at the apex; lora rather elongate, strongly developed; cardines thick and curved.

Melecta, *Latr. Hist. Nat.* xiv. p. 48. (Pl. VIII. figs. 3, 4.)

Labrum almost as long as wide, slightly narrowed, and truncately rounded in front, densely clothed with long, shortly branched hairs. Epipharynx very long, narrow, and pointed; at the side of each sclerite of the hypopharynx near the base, the investing membrane is chitinized into a dark plate, a character I have only seen in this genus. At the base of the maxillæ, lying on the membrane, are two long dark chitinous plates which I believe represent the basal scales. Maxillæ nearly black on the basal portion outwardly, membranous inwardly, bearing the sclerites mentioned above; palpi rather short, 4-jointed; blades forming two very concave sheaths, the superior portion narrow, with only a very narrow membranous edge towards the apex of their inner margins; apices with a few very short hairs. Paraglossæ very long, narrow and pointed, extending almost to the apex of the maxillæ. Lingua very long, narrow, slightly constricted at the extreme base. Beneath, with the mentum very long; labial palpi 4-jointed; 1st joint more than three times as long as the 2nd; 3rd and 4th subequal, together not quite half so long as the 2nd; 1st and 2nd joints flat, and somewhat sheath-like; 3rd and 4th cylindrical. Submentum elongate and parallel-sided, except at the extreme apex; lora and cardines very long.

Cœlioxys, *Latr. Gen. Crust. et Ins.* iv. p. 166.
(Pl. VI. figs. 4–6.)

Labrum longer than wide, parallel-sided; its apex abruptly truncate. Epipharynx hidden beneath the labrum. Scales at the base of the maxillæ strongly developed, elongate oval, fringed with long hairs, their bases hidden in the specimen before me by the labrum; sclerites of the hypopharynx strongly developed. Maxillary palpi two-jointed; apical joint very small and narrow; blades of the maxillæ pointed, submembranous, with a strong thick midrib from which a series of beautifully fine parallel striæ extend on to the membrane at each side, those on the inner side extend about halfway across the membrane, those on the outer side, which is convex, appear to extend to the exterior margin, and on the reverse or concave underside of the blade appear as ridges, which under a ½-inch objective may be

seen to be set with rows of fine short golden hairs. Lingua long, not constricted at the base; on the membranous covering of the upper surface of the mentum are two elongate, subparallel, narrow, slightly sinuate sclerites extending almost to the junction of the labial palpi; beyond these at their apical ends are two others, which diverge rather rapidly and apparently terminate near the base of the lingua; these latter seem to me to be a portion of the paraglossæ, and to represent the broad basal portion of those organs so largely developed in the short-tongued bees; the rest of the paraglossæ, *i. e.* their apical portion, appears beneath the membrane which invests the root of the lingua and extend as two straight narrow sheath-like bodies to about the apex of the 1st joint of the labial palpi. Mentum beneath slightly widened to the apex, three times or more as long as wide; 2nd joint of labial palpi twice as long as the 1st, with its inner margin submembranous; 3rd and 4th very short, cylindrical. Submentum very elongate and narrow; lora short and wide; cardines much curved, and widened about the middle.

MEGACHILE, *Latr. Hist. Nat.* xiv. p. 51. (Pl. VIII. figs. 1, 2.)

Labrum shaped much as in *Cœlioxys*, longer than wide, with nearly parallel sides and abruptly truncate apex; epipharynx hidden beneath it; scales at the base of the maxillæ stipitate, their blades about four times as long as wide, parallel-sided, and truncate at the apex, inner margins set with bristly hairs; maxillary palpi 2-jointed, blades of the maxillæ as in *Cœlioxys*, and all the upper sclerites of the mentum, paraglossæ, &c. scarcely differing from those of that genus; the first joint, however, of th' 'abial palpi is longer, almost equalling the 2nd. For the me um &c. the description of *Cœlioxys* will practically apply.

ANTHID' M, *Fabr. Syst. Piez.* p. 364. (Pl. VIII. figs. 5–7.)

In this genus again the cibarial apparatus is almost identical in form with the preceding, but the maxillary palpi are only one-jointed; and the outer half of the blades of the maxillæ are more deeply striate and set with stronger bristles; the sclerites also, which connect the mentum with the maxillæ and form the continuation of the sclerites of the hypopharynx, are much curved, a large portion of the curves showing on each side, and unite with

the mentum quite at the base instead of about a quarter of its length from it; the lora are very wide at their bases; the cardines long and slightly curved.

STELIS, *Panz. Krit. Rev.* ii. p. 246.

Of this I have only dried specimens, but the sclerites all appear to be arranged as in *Anthidium*; but the 2nd joint of the labial palpi is nearly twice as long as the 1st, and the 3rd is widened and somewhat flat, about equal in length to the 4th.

OSMIA, *Panz. Krit. Rev.* ii. p. 230. (Pl. VII. figs. 4–6.)

Labrum elongate, as in the preceding genera, but more rounded at the sides. Scales at the base of the maxillæ very strongly developed, subparallel-sided for two-thirds of their length, the outer sides thence rounded to the apex; inner margins set with long hairs; maxillary palpi 4-jointed; blades very long and pointed, with a strong longitudinal rib. Sclerites of the membranous covering of the mentum as in *Cœlioxys*, &c.; those of the upper part of the paraglossæ longer and narrower; the lower or blade-like portion of the paraglossæ rounded at the apex, and extending to about three-fifths of the length of the 1st joint of the labial palpi. Lingua very elongate; labial palpi with the 2nd joint once and a half as long as the 1st; apical joints very short; sclerites connecting the maxillæ with the mentum, joining the latter close to its base; submentum very long and narrow, widened at the apex; lora elongate, wide at their bases; cardines rather narrow and slightly curved.

CHELOSTOMA, *Latr. Gen. Crust. et Ins.* iv. p. 161. (Pl. VII. figs. 1–3.)

Labrum elongate, slightly sinuate at the sides, truncate or slightly emarginate in front. Scales of the maxillæ hidden beneath the labrum. Maxillary palpi 3-jointed; blades of the maxillæ broadly membranous on their inner margin. Sclerites of the upper surface of the mentum as in *Cœlioxys*, &c.; those of the paraglossæ which were noted in that genus as apparently belonging to those organs, here show their connexion most plainly, and appear as elongate divergent dorsal plates, whereas the rest of the paraglossæ, extending below and beyond them, forms a sort of lateral sheath to the base of the lingua, its upper edge being set with bristly hairs. Lingua elongate, linear,

nearly twice as long as the first two joints of the labial palpi. Mentum beneath about $3\frac{1}{2}$ times as long as wide, slightly widened towards the apex, where it is deeply trilobate. Labial palpi with the first three joints sheath-like, and only the apical one cylindrical and divergent; the basal joint is very short, not a quarter so long as the 2nd, the 3rd is about half as long as the 1st, and the 4th distinctly longer than the 3rd. (I must here correct an error which, I regret to see, occurs in my synopsis, Trans. Ent. Soc. Lond. 1884, p. 213. I there say of the labial palpi "apical joint much shorter than 3rd;" and I may remark also that F. Smith, in his 'Catalogue of British Hymenoptera,' pt. 1, figures this genus on pl. viii. as having the apical joint very short, and I fear I must have taken my measurements from him.) Submentum short, in the form of an elongate triangle; lora strongly developed; cardines long and slightly curved.

Heriades, *Spin. Ins. Lig.* ii. p. 7.

I have only dry specimens of this genus, but the maxillæ and the upper sclerites of the mentum and the paraglossæ appear to be arranged much as in *Chelostoma*; the labial palpi differ from those of the species of that genus in having the terminal two joints divergent and cylindrical, instead of only the terminal one; the submentum is very elongate, and the lora has very long arms; the maxillæ at the base are clothed with very long plumose hairs; the cardines are long and straight.

Eucera, *Scop. Ann. Hist. Nat.* iv. p. 8. (Pl. IX. figs. 1–3.)

Labrum semicircular; epipharynx angularly pointed; membranous base of the maxillæ bearing two small narrow sclerites, widening towards their apex and approaching each other apically, dark at their base and nearly hyaline at their apex; at the base of the hyaline portion near its exterior margin is a small dark spot out of which rises a bristle, and there are two other bristles emerging from the dark portion. These sclerites appear to me to be homologous with the scales in the other genera, although much less developed; from their bases extend two other much larger sclerites, of a pale horn-colour, elongate, slightly widened at the apex, adpressed to the membrane, with their exterior apical angles rounded; they reach almost to the base of the dark opaque portion of the maxillæ: I have seen nothing like them in

any other genus; whether they are branches of the scales or what I cannot say, but they appear to be connected with them. Maxillary palpi 5-jointed; blades of maxillæ widely membranous on their inner margin, especially at the apex; the thickened external rib produced at the apex in the form of a hook: base or dorsal plates of the paraglossæ, when these organs are closed, ensheathing the base of the lingua; the lateral portions of the paraglossæ extend from behind the middle of the dorsal sheath in very long, slightly curved processes to beyond the apices of the labial palpi; their inner margins widely membranous at the base, the membrane gradually narrowing towards the apex, and disappearing at a point about a quarter of the entire length of the paraglossæ from the apex. Lingua very elongate; mentum beneath elongate, parallel-sided, receiving the sclerites of the hypopharynx near the base; 1st and 2nd joints of labial palpi very wide, their inner margins widely membranous, 1st nearly twice the length of the 2nd, 3rd and 4th short, cylindrical and divergent. Submentum very long; arms of the lora very long and strongly developed; cardines wide and slightly curved; base of the maxillæ clothed with very long plumose hairs.

ANTHOPHORA, *Latr. Nouv. Dict. d'Hist. Nat.* ix. p. 167. (Pl. IX. figs. 7–9.)

In this genus the labrum is transverse, largely rounded in front, the apex of the epipharynx shows beyond it, narrow, truncate at the apex, with the corners of the truncature rounded. The scales of the maxillæ are oval, strongly developed, and set with strong testaceous bristles along their margins. The sclerites of the hypopharynx are very divergent, and extend under the maxillæ to beyond their palpi, whence they approach the submentum at right angles, just at its juncture with the mentum. The maxillary palpi are 6-jointed; the blades of the maxillæ are long, narrow, convex above, with a narrow parallel membranous inner margin, through which, near the apex, a few hairs can be seen fringing the thicker portion on its concave side. Sides of the mentum produced and folded over the upper surface, their edges touching each other for a short distance about the middle and then diverging rapidly to the base of the labial palpi; these are attached more laterally than in any of the preceding genera, and their attachment can be plainly seen from above; the basal

joint is exceedingly long and sheath-like, its inner margin widely membranous, and its midrib set with hairs; these hairs much resemble those of the maxillæ, which show through the membranous inner margin of those organs in so many genera; the 2nd joint is about a third as long as the 1st, also sheath-like; the 3rd and 4th are very short, subequal, cylindrical, and divergent. Beyond the divergent sides of the mentum above are seen two sclerites which terminate at the base of the paraglossæ; these latter organs are most strongly developed; their bases are truncate, their inner edges overlap, thus forming a complete dorsal sheath for the base of the tongue; the apices of these dorsal sheaths are rounded exteriorly; from about their middle originate the lateral or blade-like portions of the paraglossæ, which extend as latero-ventral sheaths to about as far again as the dorsal ones—*i. e.*, to about two thirds of the length of the 1st joint of the labial palpi. The lingua is exceedingly long, longer than in any other genus of our British Anthophila; the base of the lingua beneath is also sheathed by two sclerites, which appear to be ventral portions of the paraglossæ. Mentum subparallel-sided, at the apex emarginate, but with its centre produced into a pale angular process; submentum exceedingly long and narrow; arms of the lora short but wide at their union; cardines short and narrow.

SAROPODA, *Latr. Gen. Crust. et Ins.* iv. p. 177. (Pl. IX. figs. 4–6.)

Only distinguishable generically from *Anthophora* by the 4-jointed maxillary palpi and the 2-jointed labial palpi, both of which are sheath-like. How F. Smith and Dours managed to find a 3rd and 4th joint I fail to understand.

CERATINA, *Latr. Hist. Nat. Ins.* xiv. p. 50.

Of this genus I have only dried specimens. Labrum subquadrate; epipharynx long and pointed; scales at the base of the maxillæ largely developed, bearing a few long hairs. Maxillary palpi 6-jointed; blades of the maxillæ with their inner margin widely membranous, through which can be seen the long hairs that fringe the thicker part of the blade on its underside. Paraglossæ sheath-like, their apices situated at about two-fifths of the length of the 1st joint of the labial palpi from its base.

Lingua very elongate. Mentum elongate; labial palpi with the first two joints sheath-like, the 2nd nearly as long as the 1st, 3rd and 4th very short, divergent; submentum very long, and the arms of the lora likewise.

Psithyrus, *Lep. Ann. Soc. Ent. Fr.* ii. (Pl. X. figs. 1–3.)

Labrum transverse, widely rounded in front, the centre of the front margin slightly produced; epipharynx triangular; scales of the maxillæ small, but bearing several long bristles. Maxillary palpi 2-jointed; blades of the maxillæ elongate, their apices slightly incurved and hook-like, their inner margins widely membranous, showing the hairs which fringe the thicker part of the blade beneath very clearly. Paraglossæ with their dorsal plates pointed at the apex, the base bearing a few lateral hairs; lateral portions sheath-like, rounded at the apex. Lingua very long. Mentum beneath parallel-sided, truncate at the apex; 1st and 2nd joints of the labial palpi very wide and sheath-like, with wide membranous inner margins, 2nd about one fourth as long as the 1st, 3rd and 4th very short, cylindrical and divergent. Submentum shortly pyriform. Sclerites of the hypopharynx joining the mentum at some distance from the base; lora with short curved arms; cardines nearly straight.

Bombus, *Latr. Hist. Nat. Ins.* xiv. p. 63. (Pl. X. figs. 4–6.)

So like *Psithyrus* in all its details that there really is no object in giving a special description of them; for particulars, therefore, see that genus.

Apis, *Linn. Syst. Nat.* ed. x. 1. p. 574. (Pl. X. figs 7, 8.)

Labrum widely transverse, rounded in front; epipharynx pointed; scales at the base of the maxillæ not represented as far as I can see. Maxillary palpi 1-jointed; blades of the maxillæ very widely membranous inwardly, their apices with a few short bristly hairs. Paraglossæ ensheathing the lingua at its base, produced at their apices into two rounded, hyaline lobes; lingua elongate. Mentum beneath short, twice and a quarter as long as wide, its apex truncate. Labial palpi with the 1st joint widely membranous on its external margin, fringed with long hairs on its internal margin, and set with long stiff bristles on its dark

central portion; 2nd joint not a sixth as long as the 1st, 3rd and 4th divergent, very short, cylindrical. Submentum short and triangular; lora with the arms short but well developed; cardines very slightly curved. In the queen all the parts are shorter and stouter.

EXPLANATION OF THE PLATES.

Plate III.

Fig. 1. *Colletes*: anterior view.
2. ,, posterior view.
3. *Prosopis*: anterior view.
4. ,, posterior view.
5. ,, lingua paraglossæ.
6. *Sphecodes*: anterior view.
7. ,, posterior view.
8. ,, lingua paraglossæ.
9. *Halictus*: anterior view.
10. ,, posterior view.
11. ,, base of lingua paraglossæ.

Plate IV.

Fig. 1. *Andrena*: posterior view.
2. ,, anterior view.
3. ,, base of lingua paraglossæ.
4. *Cilissa*: anterior view.
5. ,, posterior view.
6. ,, lingua paraglossæ.
7. *Macropis*: anterior view.
8. ,, posterior view.
9. ,, lingua paraglossæ.

Plate V.

Fig. 1. *Dasypoda*: anterior view.
2. ,, posterior view.
3. ,, lingua paraglossæ.
4. *Panurgus*: anterior view.
5. ,, posterior view.
6. ,, base of lingua paraglossæ.

Plate VI.

Fig. 1. *Nomada*: anterior view.
2. ,, posterior view.
3. ,, base of lingua paraglossæ.
4. *Cœlioxys*: anterior view.
5. ,, posterior view.
6. ,, base of lingua paraglossæ.

PLATE VII.

Fig. 1. *Chelostoma*: anterior view.
2. ,, posterior view.
3. ,, base of lingua paraglossæ.
4. *Osmia*: anterior view.
5. ,, posterior view.
6. ,, base of lingua paraglossæ.
7. *Epeolus*: posterior view.
8. ,, anterior view.

PLATE VIII.

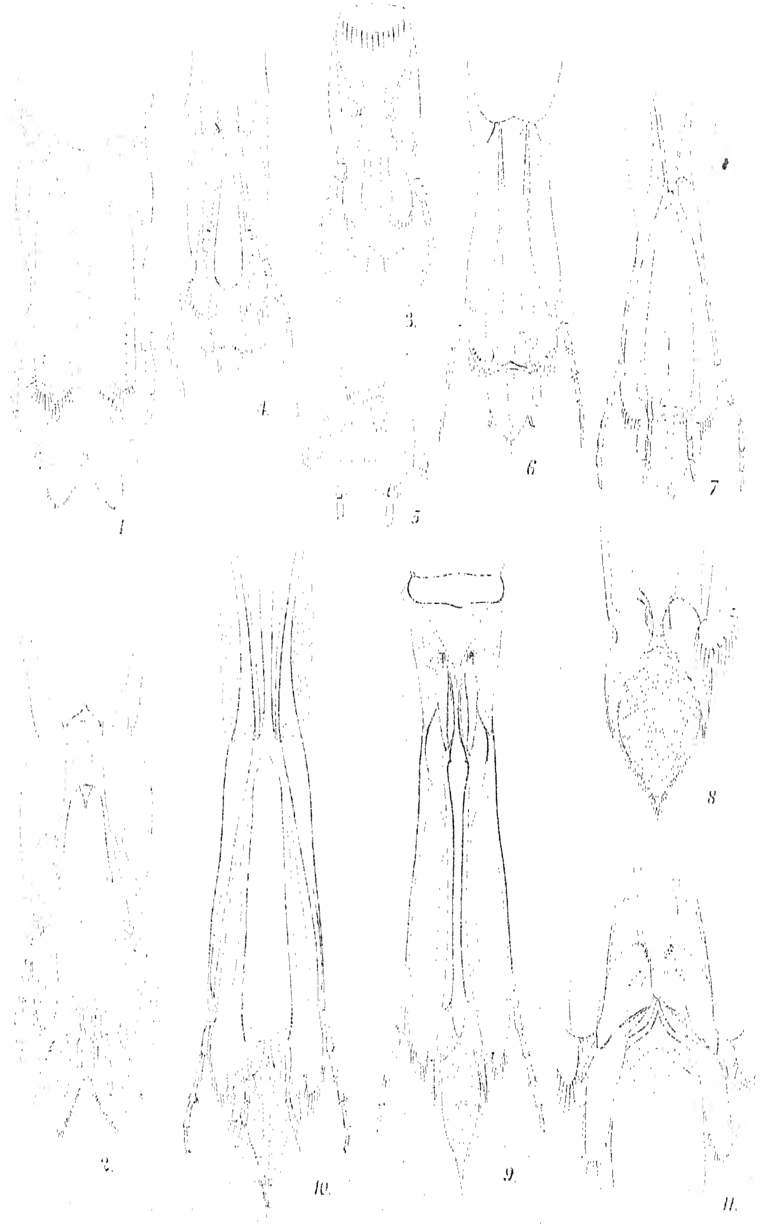
Fig. 1. *Megachile*: anterior view.
2. ,, posterior view.
3. *Melecta*: anterior view.
4. ,, posterior view.
5. *Anthidium*: posterior view.
6. ,, anterior view.
7. ,, base of lingua paraglossæ.

PLATE IX.

Fig. 1. *Eucera*: anterior view.
2. ,, posterior view.
3. ,, base of lingua paraglossæ.
4. *Saropoda*: anterior view.
5. ,, posterior view.
6. ,, base of lingua paraglossæ.
7. *Anthophora*: anterior view.
8. ,, posterior view.
9. ,, base of lingua paraglossæ.

PLATE X.

Fig. 1. *Psithyrus*: anterior view.
2. ,, posterior view.
3. ,, base of lingua paraglossæ.
4. *Bombus*: anterior view.
5. ,, posterior view.
6. ,, base of lingua paraglossæ.
7. *Apis*: posterior view.
8. ,, anterior view.



E. Saunders del. E. Wilson lith.

TONGUES OF HYMENOPTERA ANTHOPHILA.

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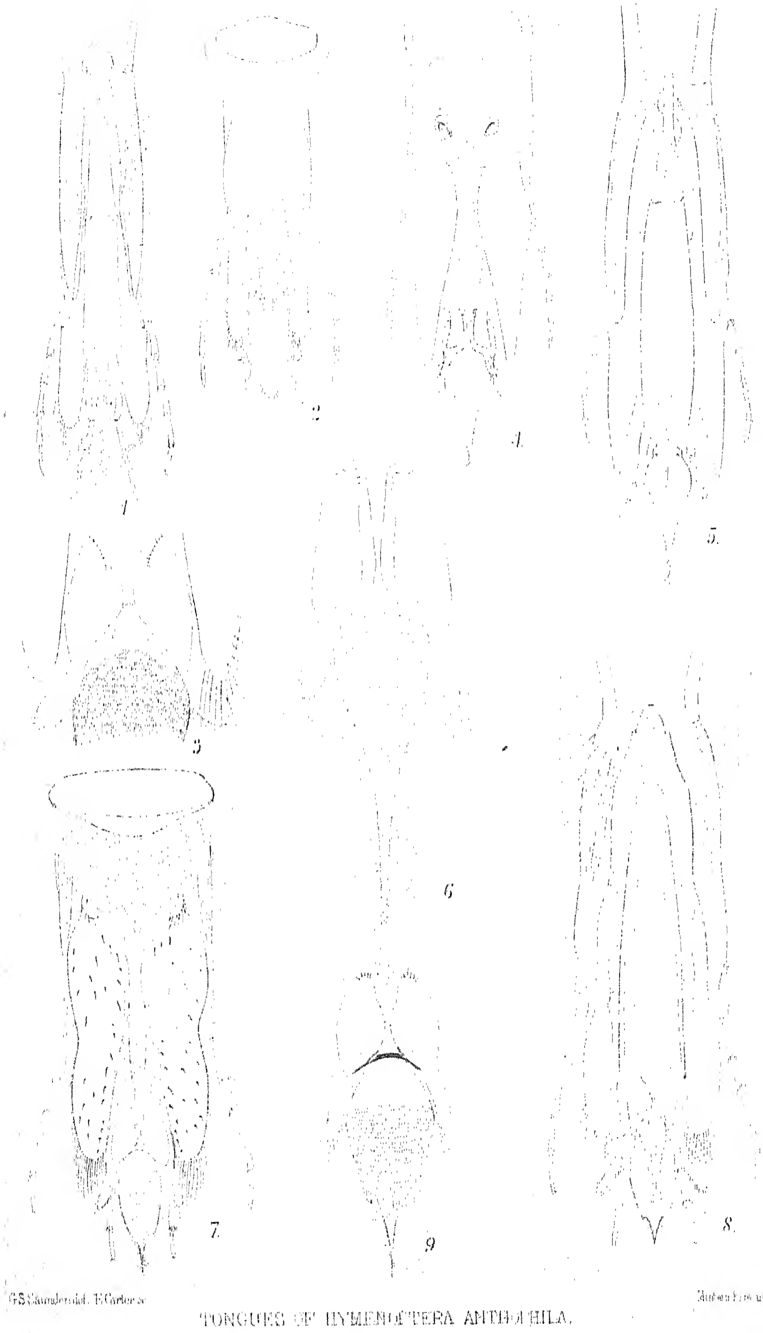

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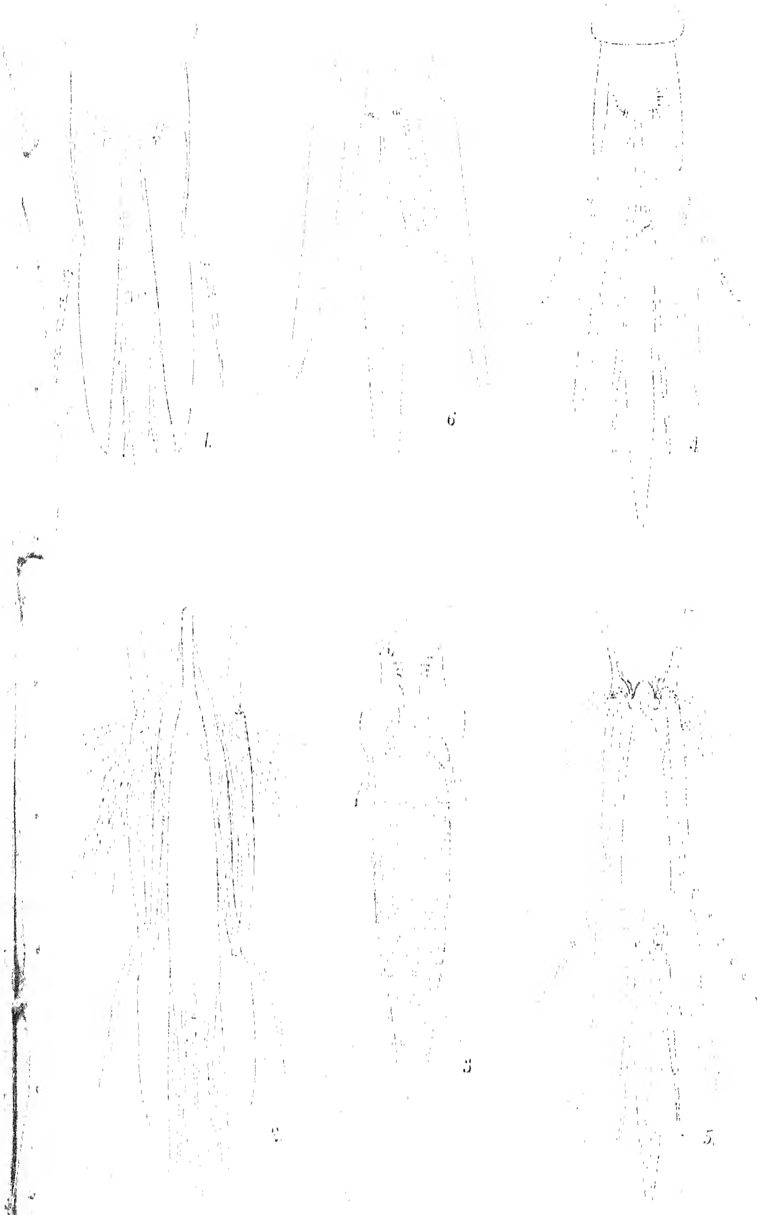

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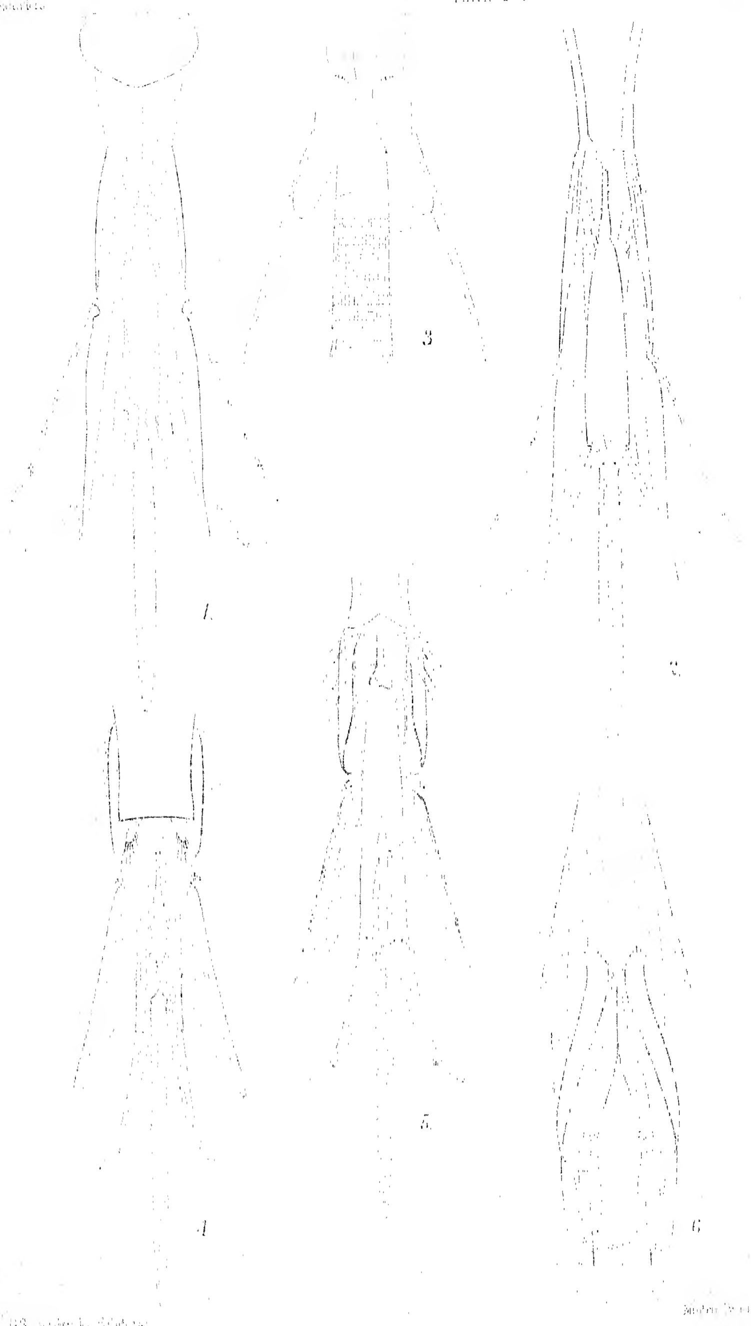

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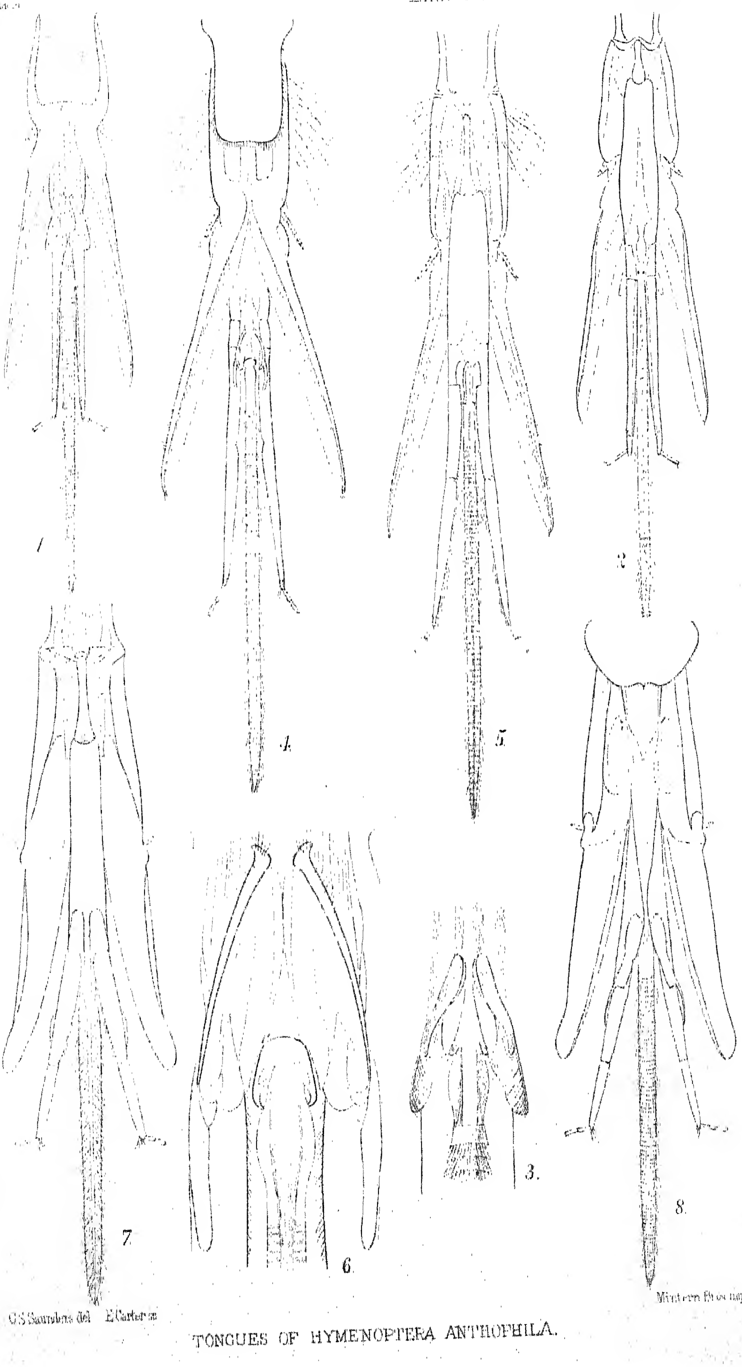

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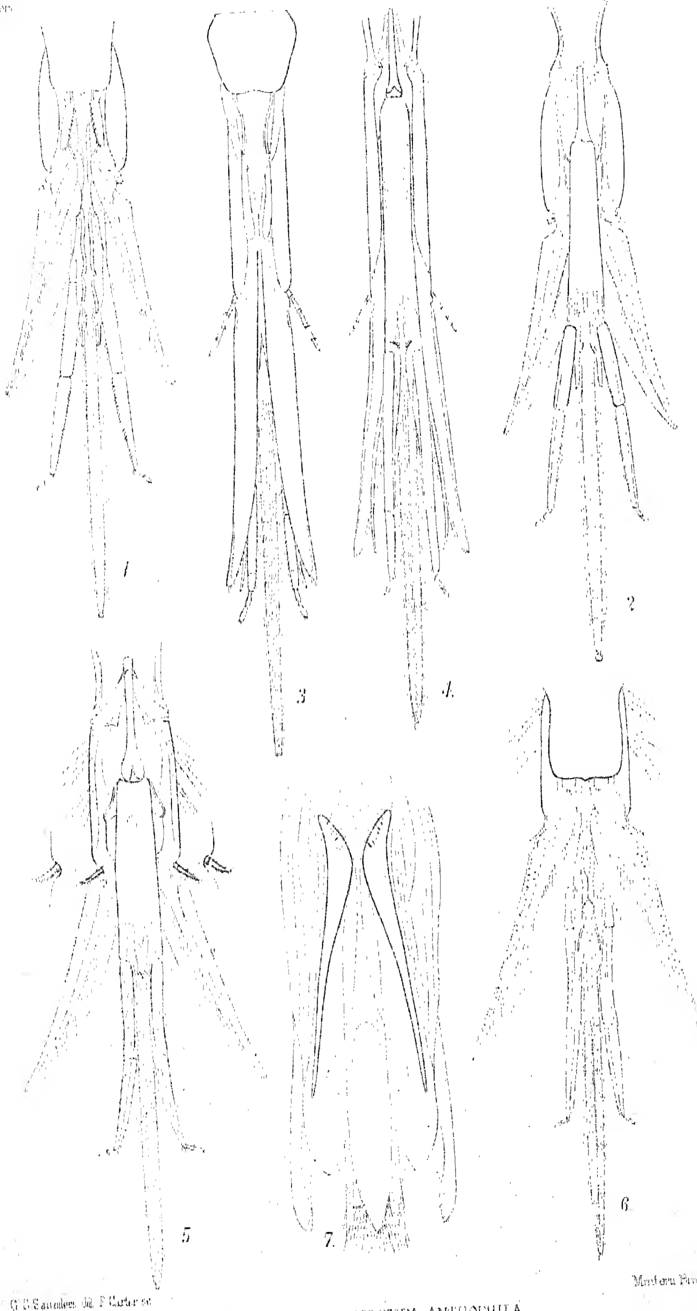

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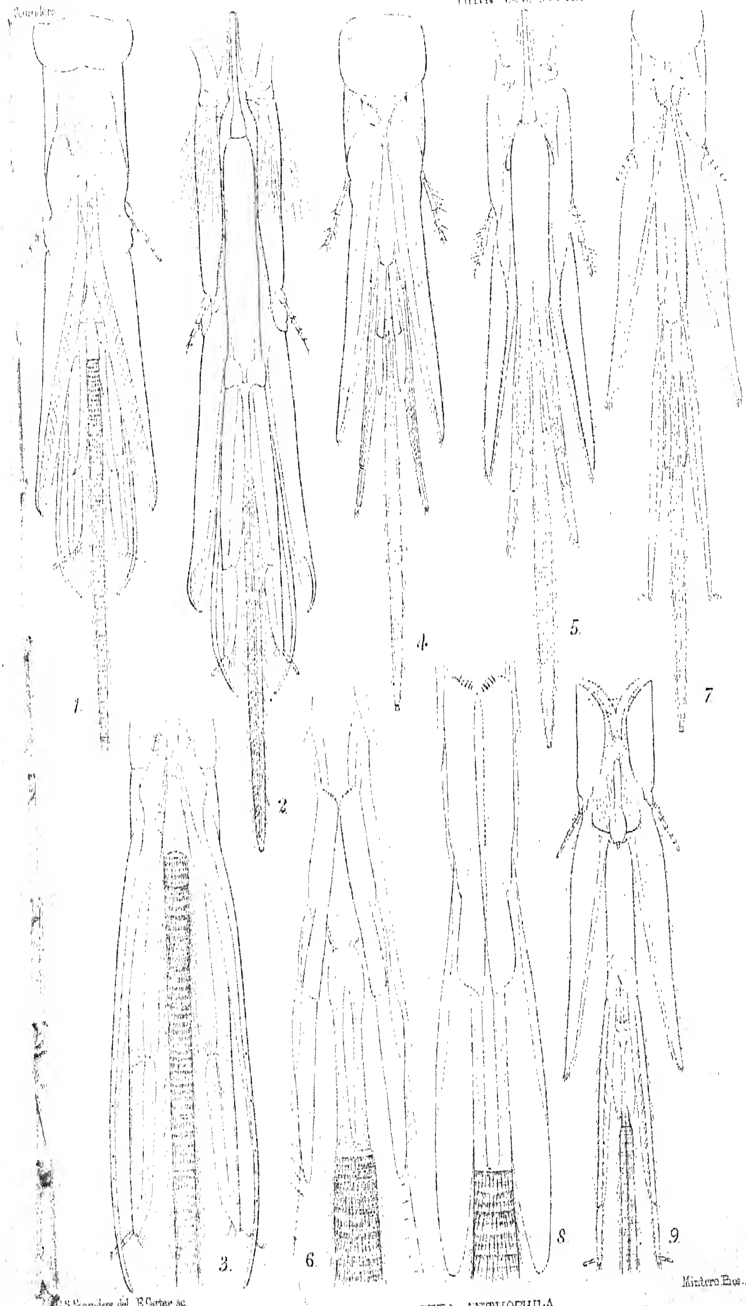

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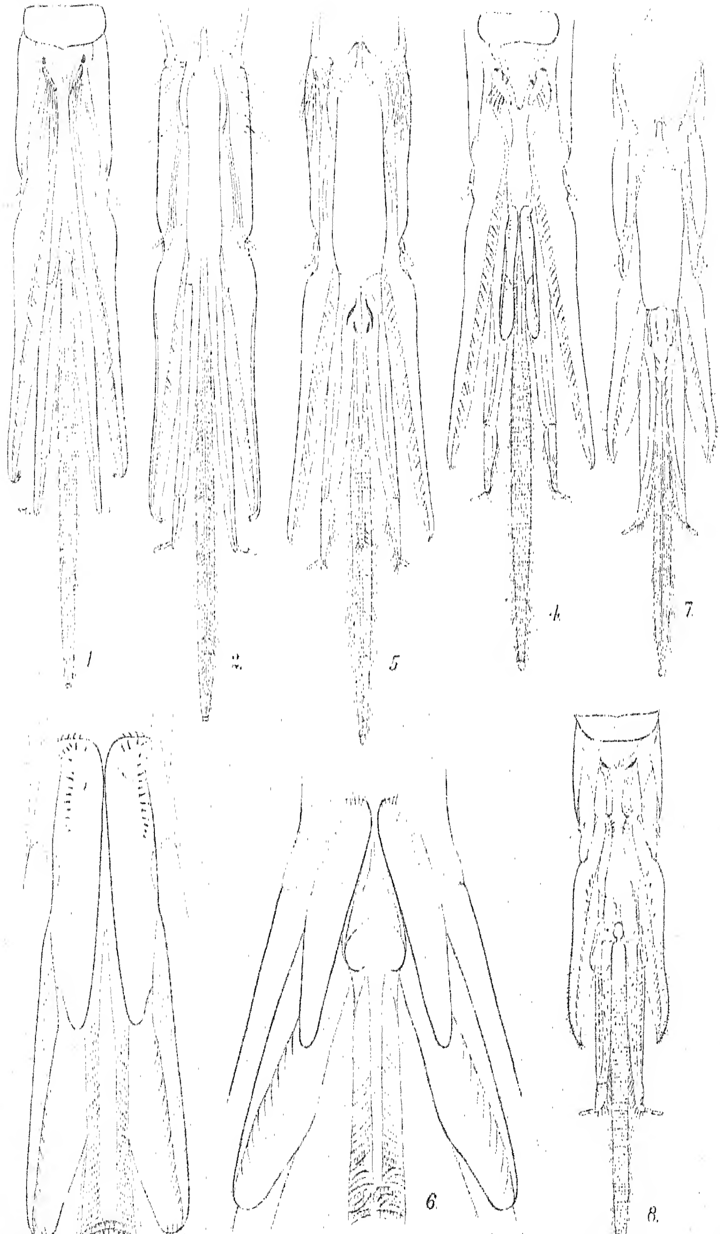

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TONGUES OF HYMENOPTERA ANTHOPHILA.

On some Old-World Species of Scorpions belonging to the Genus *Isometrus*. By R. I. Pocock, of the British Museum (Nat. Hist.). (Communicated by W. Percy Sladen, F.L.S.)

[Read 1st May, 1890.]

(Plate XI.)

The examination of the Buthidæ contained in the collection of the British Museum has brought to light a number of new species of the group. Those referable to the genus *Isometrus* are described in the present paper, which contains in addition a few remarks upon the synonymy and affinities of one or two previously known forms.

Speaking generally, *Isometrus* may be described as almost cosmopolitan, although representatives have not yet been recorded from the Palæarctic Region. However, in Central and South America, in Africa south of Sahara, in India, Indo-Malaya, Austro-Malaya, and Australia the species are fairly abundant, and the number at present known will no doubt be largely added to in years to come.

In the Old World the species may nearly always be recognized from others of the family by the variegated black and yellow pattern of the upper surface of the body and legs; in some instances, however, the limbs and trunk are concolorous or nearly so. The colours, allowing for variations, are of some use in the recognition of the species; but the best characters for this purpose are to be obtained from the form of the tail, the keels on the tail and trunk, the width of the hand, length of fingers, &c.

The sexes differ largely and in a variety of ways. The male may almost certainly be detected by possessing some one or more of the following features:—The hand will either be longer and relatively more slender, or stouter than it is in the female; at the base of the dactyli there is often a wide space formed by the sinuation of the proximal half of these organs; the trunk is more slender; the tail much or a little longer, and sometimes only thicker.

On Isometrus tricarinatus, *Simon.* (Pl. XI. figs. 1–1 *d.*) (*Simon, Ann. Mus. Genov.* xx. p. 47, 1884.)

Pondicherry, Madras.

The British Museum possesses three specimens of a species of *Isometrus* sent by Mr. Jerdan from Madras, which are unques-

tionably referable to *I. tricarinatus* of Simon. Mons. Simon h only a female for examination, and since one of the specimens in the Museum collection is a male, I take this opportunity of pointing out the sexual characters of the species.

♀. Tail much shorter, only a little more than five times the length of the cephalothorax; the first segment about as wide as long; cephalothorax about as long as the first segment and half the second, slightly longer than the fourth.

Manus about as wide as the brachium; digits in contact throughout, neither lobate nor sinuate.

♂. Tail much longer, about six times the length of the cephalothorax; width of the first segment equal to about two thirds of its length: cephalothorax very slightly longer than the first caudal segment, much shorter than the fourth.

Manus wider than the brachium; digits not quite in contact at the base, the movable furnished with a distinct lobe which fits into a sinuation of the immovable.

I. Shoplandii, Oates, is very closely allied to this form and can, I think, only be regarded as doubtfully distinct. In his description of this species Mr. Oates, to whom *I. tricarinatus* was unknown, lays considerable stress on the differences of colour between the two; but the words "*the whole animal uniform fulvous*," with which he differentiates *I. tricarinatus*, are scarcely in accord with the following sentence with which Mons. Simon's description begins, "*Obscure fulvus, pedibus dilutioribus, caudæ segmento quinto leniter infra infuscato.*" As a matter of fact, there is very little difference in colour between the two, what difference there is being noticeable principally on the under surface of the tail, which is more infuscate in *I. Shoplandii*. The upper surface of the abdomen in at least one of the specimens of *I. tricarinatus* is considerably darker than the limbs, and the tergites bear distinct traces of the fulvous >-shaped mark which is noticeable in the specimen of *I. Shoplandii* which Mr. Oates has kindly presented to the Museum. Apart, however, from colour, certain differences are undoubtedly to be seen between this specimen of *I. Shoplandii* and the three above-mentioned examples of *I. tricarinatus*. Thus, in the former the cephalothorax is slightly more emarginate in front and the anteocular area is more coarsely granular; again, the lateral tergal keels are represented only by one conspicuous granule, whereas in *I. tricarinatus* these keels are composed of about three fused granules; and, lastly, the tail

in *I. Shoplandii* seems to be more slender, and the terminal granule of the superior keels not larger than the rest.

Whether these differences will stand the test of an examination of a number of specimens from intermediate localities is a question which, for the present, must be left unanswered.

There is also in the Museum a single dried and apparently young female specimen of an *Isometrus* which came from Calcutta. This specimen differs from the type of *I. Shoplandii* in having no trace of lateral tergal keels and distinctly longer manus and digits; these taken together being longer than the first two caudal segments, whereas in *I. Shoplandii* they are slightly shorter. I have very little doubt, however, that it is referable to this species.

On Isometrus scutilus (*C. Koch*).

Syn. Lychas scutilus, *C. Koch, Die Arachn.* xii. p. 3, fig. 962 (1842).
Isometrus Weberi, *Karsch, Berl. ent. Zeits.* xxvi. p. 184 (1882).
Isometrus messor, *Simon, Ann. Mus. Genov.* xx. pp. 47, 48 (1884).
Isometrus Phipsoni, *Oates, Journ. As. Soc. Bombay*, iii. p. 248, figs. 1 & 2 (1888).

Tenasserim (*Oates*), Salanga (*Mus. Brit.*), Bintang (*Koch*), Java (*Simon*), Keeling Island (*Thorell*).

There seem to me to be very strong grounds for suspecting, with Dr. Thorell *, that *I. Phipsoni* is synonymous with *I. scutilus*. Undoubtedly, to judge from the figure and description of the latter, the two forms differ in colour; but those who are familiar with Koch's work will know what confidence is to be placed in the accuracy of the painting of the figures and in the wording of the descriptions.

In shape, length of tail and of appendages, &c., the figure of *scutilus* agrees well with the female of *Phipsoni* (of which, through the liberality of Mr. Oates, the Museum possesses many examples from Tenasserim); and the view that the two are identical is much strengthened by the fact that the Museum possesses in addition a specimen of *Isometrus* (obviously co-specific with the specimens named *Phipsoni*) from Salanga, a locality relatively so close to Bintang, whence the type of *scutilus* came.

However that may be with regard to *scutilus*, there is no question that the British-Museum specimen from Salanga is *I. Weberi*,

* Ann. Mus. Genov. (2), vii. p. 525 (1889–1890).

Karsch, a species recorded from the same locality. Consequently *Phipsoni* is synonymous with *Weberi*. Moreover, after carefully comparing Mr. Oates's specimens with the description of *I. messor*, Simon, I cannot find a single character to justify the specific separation of the specimens named *Phipsoni* from those named *messor*.

I believe, therefore, that the above synonymy is correct. If so, the species has a fairly wide range, occurring in Tenasserim, the Malay Peninsula, and Java, and, according to Thorell, as far to the east as Keeling Island.

ISOMETRUS HOSEI, sp. n. (Pl. XI. fig. 2.)

Colour: upper surface of trunk, tail, and appendages dull black, the hands, tarsal segments of legs, and vesicle with tinge of red; upper surface of chelicerae shining; pectines ochraceous; abdominal sternites and under surface of appendages with reddish tint.

Cephalothorax finely and closely granular throughout; anterior border widely and shallowly emarginate; ocular tubercle deeply and widely sulcate, the median eyes large and separated by a space equal to about half a diameter; no trace of keels running from the tubercle to the anterior margin, and the posterior keels which bound laterally and posteriorly the central cephalothoracic depression only very slightly developed.

Tergites finely granular throughout; the first six marked posteriorly with a median granular keel, the seventh marked with a short, anterior, median, granular keel and on each side with two slightly oblique granular keels which run from the hinder margin of the tergite to the middle of the plate, but do not unite in front; the third, fourth, fifth, and sixth tergites furnished posteriorly on each side of the middle with a conspicuous transverse ridge formed by an aggregation of coarser granules.

Sternites: four anterior bisulcate and almost wholly smooth, feebly granular only on the side margins; the fifth very feebly granular and armed with four granular keels, of which the two internal attain the hinder margin of the plate, while the external are situated in the middle with their extremities far from the anterior and posterior margins.

Tail somewhat slender, a little thicker at the base than at the apex; the intercarinal spaces almost wholly smooth, at most very feebly granular, the keels strongly marked but weakly granular;

the first segment with ten keels, the second, third, and fourth with eight; the fifth with six keels, whereof the median inferior is strongly developed and the superior lateral very feeble; the superior median excavation in the caudal segments, shallow on the first, becomes progressively shallower from before backwards and is almost absent on the fifth. *Vesicle* with a conspicuous but very feebly granular inferior median keel and very faint traces of a lateral keel on each side of it; aculeus slender and long, as long as the vesicle; spine under the aculeus strongly developed.

Palp.—*Humerus* with upper surface very finely granular and bounded in front and behind by a more coarsely granular ridge; anterior surface defined below by a feebly granular ridge and bearing a few larger granules; inferior surface smooth, posterior surface smooth. *Brachium* with three feebly granular keels on its upper surface, a smooth weak keel on its posterior surface, a few larger granules in front, and with smooth under surface. *Hand* narrower than brachium, furnished above with two very weak, very feebly granular keels, and in front with a few slightly larger granules. *Dactyli* long, curved, in contact throughout their extent, neither lobate nor sinuate.

Legs.—*Coxæ* smooth; *femora* granular in front, carinate and granular above and below, smooth behind; *patellæ* granular and carinate anteriorly; *tibiæ* also granular and carinate, those of the two posterior pairs armed distally beneath with a stout spine.

Pectines extending as far as, but not beyond, the distal extremity of the coxæ of the fourth pair of legs, furnished with 20–21 similar teeth and not provided with an internal basal lobe.

Stigmata slit-like.

Measurements in millimetres.—Total length 62; cephalothorax, length 7·5, width 7; tail, length 40, width at base 3·5, at posterior end of 5th segment 2·5; 1st segment, length 4·5; 2nd segment, length 5·5 (of the two together 10·5); 5th segment, length 8·3; vesicle, length 4·5, width 2·4; aculeus, length 3. Palp—humerus, length 7; brachium, length 8·5, width 3; hand, length 2·5; length of "hand-back" 4, of movable dactylus 8·5.

A single specimen, in all probability a female, from Baram in Borneo, collected by Mr. Charles Hose.

Superficially this Scorpion bears a strong resemblance to the females of the black American species *I. americanus*, *I. androcot-*

toides, and *I. insignis*. From these, however, it may be at once recognized by its keelless hands and cephalothorax and its spurred posterior tibiæ. Of the Oriental species it appears to come nearest to *I. scutilus* of Koch, but the two may be separated by their marked difference in colour, the number of pectinal teeth, &c.

ISOMETRUS INFUSCATUS, sp. n.

Colour (dry specimen) very deeply infuscate throughout; upper surface of the trunk, the tail above and below, and anterior surface of limbs obscurely variegated with fulvous spots and bands.

Cephalothorax lightly emarginate in front, covered more or less completely, but not particularly closely, with low rounded granules, which are smaller and more scattered on the anteocular area; ocular tubercle well developed, smooth and excavated between the eyes; distance between the eyes greater than a diameter.

Tergites somewhat coarsely granular throughout, the granules coarser and more close-set posteriorly; each of the first six marked with a relatively long median granular keel; the seventh with a conspicuous median, anterior, granular prominence and two well-developed granular keels on each side.

Sternites: first two smooth, third weakly granular at the sides, fourth weakly granular at the sides and behind, smooth only in the middle in front, the fifth weakly granular throughout and furnished with four subequal granular keels.

Tail robust, shallowly excavated above; intercarinal spaces very weakly granular; the terminal granule of the superior keels large and tuberculiform; the first and second segments furnished with ten evenly granular keels, the median lateral keel of the second segment, however, being considerably weaker than the rest; the third and fourth segments furnished with eight, and the fifth with five evenly granular keels. *Vesicle* smooth above, serially granular beneath; the subaculear tooth large, compressed, and armed with a distinct tubercle.

Palp.—*Humerus* weakly granular above and behind; the superior keels manifest but not coarsely granular; anterior surface furnished with a few large tubercles and bounded below by a weakly granular keel. *Brachium* above furnished with two weakly granular keels, subcostate but not granular behind, dentate in front, smooth below. *Manus* not carinate, rounded and

almost wholly smooth. *Digits* long, curved, in contact throughout their extent.

Legs with anterior surfaces granular, carinate; *tibiæ* of two posterior pairs spurred.

Pectines very short and armed with ten teeth.

Stigmata small and slit-like.

Measurements in millimetres.—Total length 35, of tail 20·5; 1st segment, length 2·3, width 3; 2nd, length and width 2·5; 3rd, length 2·7, width 2·5; 4th, length 3·2, width 2·2; 5th, length 4·7, width 2·2; vesicle, length 2·5, width 1·5. Palp—humerus, length 4; brachium, length 4·5, width 2; manus, width 1·7; length of "hand-back" 2·3; movable digit, length 5.

A single female specimen in the Museum collection ticketed Philippine Islands, from the collection of Mr. Cuming.

This species is very closely allied to *I. armillatus* (Gerv.), a species only known to me from Gervais's figure and description of it, and from the characters that Mons. Simon has mentioned in his synoptical table of the Oriental species of the genus. On the strength, however, of there being in this species of mine no trace of the black "bracelet" of the brachium and only ten pectinal teeth as opposed to eighteen in Gervais's type, I have ventured to regard it as new. This form most nearly resembles *I. armillatus* in having ten keels on the first two caudal segments, four keels on the posterior abdominal sternite, and at least the last two abdominal sternites covered with granules. In the number of its pectinal teeth it comes nearest to *Androctonus variegatus*, Gerv., from New Ireland.

Isometrus armatus, sp. n. (Pl. XI. figs. 3–3 *d*.)

Colour (specimen dried and probably somewhat faded) almost wholly fulvous, with feeble indications of fuscous markings on the upper surface of the trunk and limbs; ocular tubercle black.

Cephalothorax deeply emarginate in front, thickly covered with larger and smaller granules; the central depression smooth, deep behind; the area external to the tubercle also smooth, as also for the most part is the tubercle, the granules at the summit of the sides of the depression forming in the posterior third of the cephalothorax an indistinct keel.

Tergites thickly granular throughout, from the second to the sixth with a conspicuous median keel, the seventh with an anterior subgranular median keel and two strongly granular lateral keels,

whereof the external extends almost to the anterior margin of the tergite, and the internal has its posterior granule much larger than the rest.

Sternites: anterior three smooth, fourth weakly granular only at the sides, the fifth weakly granular throughout and furnished with four posteriorly complete, anteriorly abbreviated granular keels.

Tail moderately strong, not elongate, almost parallel-sided; intercarinal spaces weakly granular; all the keels of the first four segments strongly granular; the first segment furnished with ten complete evenly granular keels, whereof the four superior are more strongly developed behind than in front; the second segment also furnished with ten keels, but the median lateral keel is weaker than the rest, each of the four superior keels elevated behind into a large tooth, these teeth on the superior keels greater than those on the superior lateral keels; third and fourth segments furnished with eight granular keels; the superior keels of the third developed behind into an enormously long and strong erect tooth; a similar, but smaller tooth on the superior keels of the fourth segment; superior lateral keels of the third bearing distally a large tooth, the corresponding keel on the fourth segment evenly granular throughout; fifth segment convex above, with a shallow median sulcus, the superior keels very weakly granular, a few strong granules only close to the vesicle, inferior lateral keels evenly granular throughout; inferior surface very convex, the median keel well expressed and strongly granular, almost tubercular behind; in the anterior half the granules on each side of it form a single longitudinal series, and posteriorly there are on each side a few irregularly arranged large tubercles. *Vesicle* slender, granular and costate beneath, the spine well developed; the aculeus of the ordinary form.

Palp.—*Humerus* with the upper keels granular and the well-developed space between them very feebly granular; posterior surface with weakly granular keel; anterior surface bearing several large tubercles and a finely granular keel below. *Brachium* above with three well-developed keels, whereof the two posterior are only subgranular; anterior surface armed with a few large and sharp tubercles; inferior surface subcostate and weakly granular. *Manus* much rounded and swollen, wider than the brachium, very feebly granular and subcostate above. *Digits* long and slender, curved and subcostate; the immovable digit at

the base bearing a distinct lobe, on the distal side of which is a distinct sinuation, the opposite (external superior) surface being convex to correspond with the sinuation; the movable digit sinuate and lobate to correspond with the lobe and sinuation of the immovable digit.

Legs strongly granular and costate; *tibiæ* of two posterior pairs armed distally with a spur.

Pectines long, projecting beyond the fourth coxæ, furnished with 19 similar teeth.

Measurements in millimetres.—Total length 43, tail 28; 1st segment, length 3, width 3·5; 2nd, length 4, width 3; 3rd, length 4·3; 4th, length 5; 5th, length 7, width 3; vesicle, length 3·5, width 2, height 2. Palp—humerus, length 5; brachium, length 5·5, width 2; manus, width 2·5, length of "hand-back" 3·5; movable digit, length 5·7.

A single male specimen from Port Essington on the N. coast of Australia, from Dr. Richardson's collection*.

This species is related to *I. variatus*, Thorell. The male of this last-named form is described and figured in Count Keyserling's 'Arachniden Australiens—Scorpiones,' pp. 9–11, and figured, as also is the female, on pl. i. An examination of this figure shows clearly the points of difference between the two species. Thus in *I. variatus* each of the four anterior caudal segments is provided with a tooth, and the teeth are approximately equal in size, whereas in *I. armatus* the second, third, and fourth only are dentate and the tooth of the third is considerably larger than the others; again, in *I. variatus* there is no sinuation in the digits such as is met with in *I. armatus*, and the manus is not wider than the brachium; the manus with its dactyli, too, is much shorter, being only slightly longer than the first two caudal segments, whilst in *I. armatus* it is almost as long as the first two and half the third.

ISOMETRUS SERRATUS, sp. n. (Pl. XI. figs. 4–4 *b*.)

Colour (dry specimen): prevailing colour ochraceous or fulvous, variegated with black; ocular tubercle black; anteocular area of cephalothorax infuscate; tergites mostly ochraceous, each, except the last, marked posteriorly with a lateral fuscous spot on each

* Since the above was written, I have come across a female specimen of this species, and have figured it on Pl. XI. fig. 3. It differs from the male in that the hand and dactyli are of normal form and the caudal spines much smaller.

side and a median wide fuscous patch; this median patch interrupted on each side of the median keel by a single conspicuous subcircular testaceous spot; tail infuscate beneath; legs fuscous, variegated with testaceous spots; humerus and brachium resembling the legs in colour; manus wholly pale, digits infuscate.

Cephalothorax lightly emarginate in front, finely and closely granular throughout; the median depression deep behind, shallow over the tubercle, widened behind and in front of it.

Tergites thickly covered with larger and smaller granules, the first six furnished with a long median granular keel, the last with a median granular keel in its anterior half and two long, anteriorly abbreviated, subparallel, granular keels on each side.

Sternites almost wholly smooth, the last furnished with four long granular keels, whereof the external are more complete than the internal.

Tail long, slender, and nearly parallel-sided; upper surface scarcely excavated; the intercarinal spaces at most very weakly granular; the first segment furnished with ten weakly denticulate keels, whereof the median lateral is obsolete in front; the second and third segments furnished with eight keels similar to those on the first; the terminal denticle of the four superior keels on each of these segments very much enlarged and bluntly spiniform; the two superior keels of the fourth segment almost obsolete, the inferior keels resembling those of the preceding segment; the fifth segment weakly granular above but without keels, the inferior keels resembling those of the preceding segment.

Vesicle absent.

Palp.—Upper surface of *humerus* with two granular keels, posterior surface granular and weakly dentate, anterior surface armed with larger and smaller teeth; *brachium* also furnished with larger and smaller teeth in front, furnished with weakly granular keels above and below. *Manus* large and round, subdentate in front, subcostate but not granular above; digits long, slender, curved and costate, somewhat widely separated at the base owing to the deep sinuation of the immovable digit; the movable not furnished with a basal lobe.

Legs granularly costate; inferior surface of the *femora* distinctly and coarsely serrate; *tibiæ* of two posterior pairs furnished with a small apical spur.

Pectines absent.

Measurements in millimetres.—Total length (without vesicle)

54, of trunk 17; 1st caudal segment, length 5·5, width 2·7; 2nd, length 6·5; 3rd, length 7·5; 4th, length 8·3; 5th, length 9, width 2·5. Palp—humerus, length 6; brachium, length 8, width 2·7; manus, width 3, length of "hand-back" 4·2; movable digit, length 7·5.

A single male specimen from Round Island (near Mauritius), collected by Col. Pike, U.S. Consul, and presented to the British Museum in 1870 by Sir Henry Barkly.

Although, owing to its dried state and the absence of the pectines and of the vesicle, a full diagnosis of this specimen has been rendered impossible, I have had no hesitation in describing it as the representative of a new species. Of all the species known to me, it appears to be most nearly allied to the Indo-Malayan form *I. scutilus* of Koch. It may, however, be at once recognized from this by its dilated hand, sinuate finger, and by the strongly spiniform nature of the terminal tooth of the superior keels on the first three caudal segments.

ISOMETRUS BURDOI, *Simon*. (Pl. XI. fig. 5.)

(*Simon*, *Bull. Soc. Ent. Belg.* 1882, p. lviii.)

Colour testaceous or ochraceous, variegated with black or fuscous patches, spots, or lines. Cephalothorax, with ocular tubercle and anteocular area, infuscate; a more or less interrupted, longitudinal, fuscous band runs from the area of the lateral eyes to the posterior margin; the posterior half of the sulcus fuscous; the postero-lateral portions bearing a patch of black which corresponds in position to a patch on each of the tergites; on the sides are two or three oblique, short, fuscous bands. Upper surface of the abdomen bearing three parallel, longitudinal, fuscous bands, whereof one is median and one on each side; the median band more or less completely divided into two by a testaceous spot which occupies the centre of each tergite; the lateral bands, also, more or less broken up by testaceous spots; the sides of the tergites, except for a single anterior black spot, testaceous; under surface of trunk testaceous, the posterior sternite only being slightly infuscate laterally. Upper surface of the tail mostly pale, sometimes with a median fuscous spot on the segments; the sides and inferior surface clouded with fuscous or black patches; the under surface and sides of the fifth segment uniformly fuscous; vesicle mostly fuscous, with more or less faint traces of pale lines; aculeus paler externally than

distally. Upper surface of cheliceræ infuscate. Palp, with humerus, pale beneath, marked above by a median fuscous band; brachium infuscate above and below, deeper in tint above; manus testaceous; dactyli fuscous, with testaceous tips. Anterior surface of legs variegated; femora marked by two spots; patellæ, tibiæ, and two tarsal segments each marked proximally by a fuscous band.

Cephalothorax widely emarginate in front; the median sulcus deep behind, shallow over the ocular tubercle and in front; the anteocular area finely and closely granular throughout, the posterior regions much more coarsely granular; ocular tubercle finely and sparsely granular.

Tergites granular throughout; except the last, marked with a median posterior granular keel: the last marked in front with a median rounded prominence and on each side with two coarsely granular keels.

Sternites smooth, very sparsely hairy; the posterior without a trace of keels, very faintly granular at the sides.

Tail robust, thicker at the base than at the apex, moderately excavated above, finely granular at the sides and above and, on the posterior segments, beneath; the first segment marked with eight granular keels, the two inferior keels being obsolete and the median lateral keel well-developed; the second also has the inferior keels obsolete, and the median lateral keel not developed, or at most but slightly represented; the third and fourth segments marked with eight keels; the fifth with five keels; the four superior keels of the first four segments very strongly developed and terminating in a longer tooth; the superior keels of the fifth very finely and evenly granular throughout. *Vesicle* very slender, smooth above, subserially granular or tubercular beneath; spine beneath the aculeus strong and simple.

Palp.—Superior and anterior surfaces of *humerus* finely and closely granular, the posterior, two superior, and antero-inferior keels strongly granular; the anterior surface tubercular and the inferior surface minutely granular proximally. *Brachium* costate and very sparsely granular above, tubercular in front, smooth behind and below. *Manus* rounded and almost smooth, furnished only on the anterior border with one or two sharp tubercles; narrower than the brachium. *Dactyli* long and curved; the larger lateral teeth set close together on each side of the main series.

Cheliceræ with movable dactylus armed above with three, below

with two teeth; the tooth on the inferior edge of the immovable dactylus well developed.

Legs in front granular and costate; *tibiæ* of two posterior pairs spurred beneath at apex; *coxæ* smooth.

Pectines not extending beyond the extremity of the fourth coxæ, furnished with seventeen similar teeth.

Stigmata slit-like.

Measurements in millimetres.—Total length 40; cephalothorax, length 4·5, width 5; tail, length 13·5, of first two segments 5·5, of 5th segment 5; width of 1st segment 2·7, of 5th 2; vesicle, length 2·7, width 1·5. Palp—humerus, length 4; brachium, length 4·4, width 1·8; manus, width 1·4; "hand-back," length 2; movable dactylus, length 4·6.

Two specimens, both apparently females, sent by the Universities' Mission from Lake Nyassa, and a third specimen, also a female, taken at Taveita (Kilima Njaro) by Mr. F. J. Jackson. This specimen from Kilima Njaro differs in some slight particulars from those collected near Lake Nyassa, which have been described above; thus the inferior surface of the tail is much more deeply infuscate; the inferior keels of the first two caudal segments and the superior keels of the fifth are more strongly developed; the vesicle is more coarsely granular, and there are only fourteen pectinal teeth.

This species may be recognized by the absence of keels on the last abdominal sternite.

Isometrus asper, sp. n.

Colour deeply infuscate, variegated with fulvous spots and bands; ocular tubercle black, anteocular region spotted fulvous, lateral and posterior regions of the cephalothorax marked with oblique black and fulvous bands; the middle of each tergite marked with a black T-shaped spot, the cross-bar of the T running along the posterior margin; the rest of the tergites marked with six irregular-shaped, more or less interrupted longitudinal fulvous bands; two of these bands are situated on the lateral margins and each terminates on the posterior margin in a more conspicuous, subcircular, fulvous spot, so that the posterior margins of the tergites are marked with six yellow spots; tail variegated throughout, the fulvous tints taking the form of well-defined subcircular spots; upper surface of humerus and brachium

similarly marked with fulvous spots; hand infuscate, and adorned with black lines; dactyli wholly fulvous; legs marked with transverse black lines; the last tergite and the posterior half of the one that precedes it infuscate and spotted with yellow.

Cephalothorax thickly and coarsely granular throughout; the central depression deeply marked behind, shallow over the tubercle and in front; the centre of the tubercle smooth, the sides feebly granular; anterior margin of cephalothorax more deeply excavated in the middle.

Tergites coarsely and closely granular throughout, the first six with a well-developed median granular keel, the last with a median granular prominence and two lateral granular keels on each side.

Sternites: first three smooth, the fourth granular at the sides, the fifth granular throughout, marked with two internal, anteriorly abbreviated, granular keels, and on each side a short external granular keel abbreviated anteriorly and posteriorly.

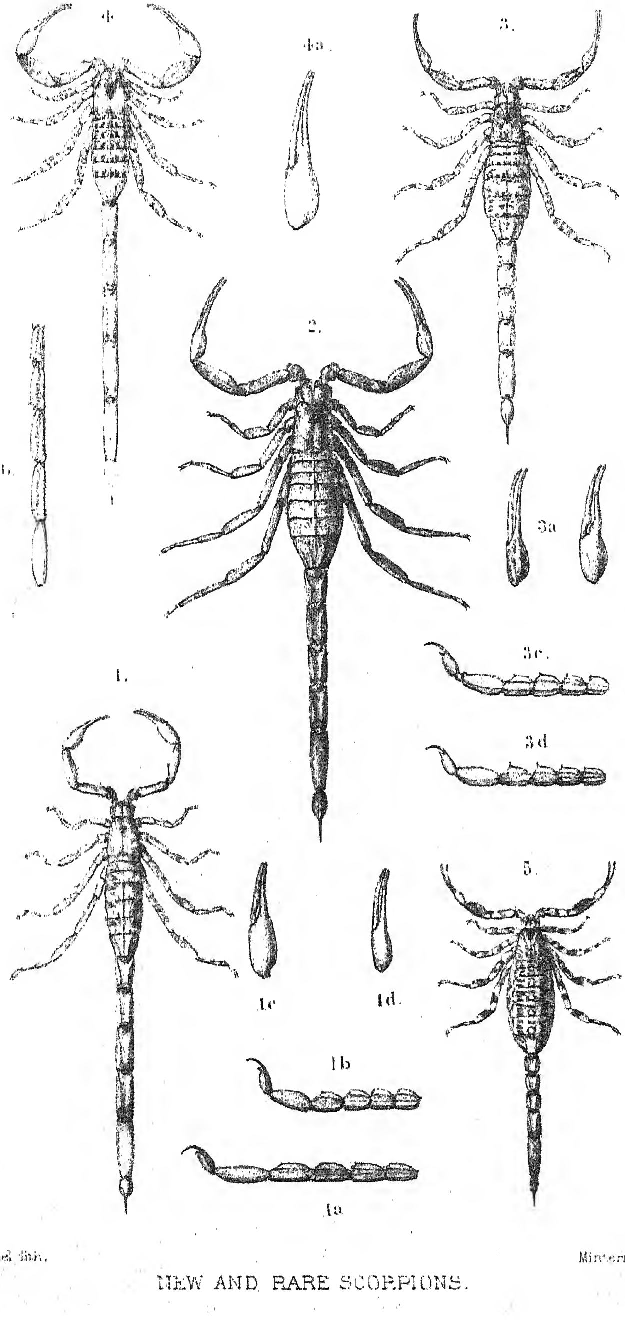
Tail of medium size, moderately excavated above: intercarinal spaces granular; keels well developed and granular; the first and second segment with ten keels, the third and fourth with eight, the fifth with five; terminal granule of the superior keels the largest; upper surface of the fifth segment almost flat.

Vesicle marked beneath with five rows of granules; the spine large, sharp, and compressed; aculeus of the ordinary form.

Palp.—Upper surface of *humerus* coarsely granular throughout and bounded behind and before by a coarsely granular ridge; posterior surface marked with a granular keel; anterior surface coarsely granular in its upper half, bounded below by a finely granular ridge; very finely granular beneath. *Brachium* weakly granular above, but furnished with three granular keels, tubercular in front, almost smooth below, marked behind by a smooth keel. *Hand* almost smooth, furnished in front with a few low weak tubercles, and above with a short series of small granules which appears to be the continuation of a keel on the immovable digit; *digits* long and curved, in contact throughout, neither lobate nor sinuate. Anterior and upper surface of the *legs* granular and granularly costate; *tibiæ* of last two pairs armed distally with a spur; *coxæ* smooth.

Pectines short, furnished with 14 similar teeth.

The male differs from the female in being more elongate (*cf.* measurements), in having longer pectinal teeth, and the superior



Michael lith.

Mintern imp.

NEW AND RARE SCORPIONS.

keels on the fifth caudal segment less developed, and in the slight basal separation of the dactyli.

Measurements in millimetres.—♀. Total length 30; cephalothorax, length 3·5, width 3·8; length of tail 17·3, of first two segments 4·3, of fifth 4·5, of vesicle and aculeus 4·2; width of first segment 2·2, of fifth 2; length of humerus 3, of brachium 3·7; width of brachium 1·4, of manus 1·2; length of "hand-back" 2, of movable dactylus 3·5.

♂. Total length 36·5; cephalothorax, length 3·8; length of tail 23, of first two segments 6, of fifth 6, of vesicle and aculeus 4·2; width of first segment 2·2, of fifth 1·7; humerus, length 3·7; brachium, length 4·5, width 1·5, of manus 1·5; length of "hand-back" 2·3, of movable dactylus 4.

The Museum has two specimens, a female from Angola (*Dr. Welwitsch*), and a male from the Congo, collected by Andrew Curror, Esq., Surgeon R.N.

This species appears to be allied to *Tityus clathratus*, C. Koch, a species from the Cape of Good Hope, which is very likely referable to the genus *Isometrus*. But in *T. clathratus* the superior caudal keels are much elevated and strongly toothed.

I can make nothing of the description of *Lychas mabillanus*, Rochebrune*. This species is recorded from Gambia and declared to be different from *Lychas gabonensis* (= *I. maculatus*, De Geer). At all events it at least differs from *I. asper* in having twenty pectinal teeth.

EXPLANATION OF PLATE XI.

Fig. 1.	*Isometrus tricarinatus*, Simon, ♂, nat. size.		
1 *a*.	,,	,,	tail of ♂.
1 *b*.	,,	,,	tail of ♀.
1 *c*.	,,	,,	hand of ♂.
1 *d*.	,,	,,	hand of ♀.
2.	,,	*Hosei*, sp. n., ♀, nat. size.	
3.	,,	*armatus*, sp. n., ♀, nat. size.	
3 *a*.	,,	,,	hand of ♀.
3 *b*.	,,	,,	hand of ♂.
3 *c*.	,,	,,	tail of ♀.
3 *d*.	,,	,,	tail of ♂.
4.	,,	*serratus*, sp. n., ♂, nat. size.	
4 *a*.	,,	,,	hand of ♂.
4 *b*.	,,	,,	tail of ♂.
5.	,,	*Burdoi*, Simon, ♀, nat. size.	

* Bull. Soc. Philom. (7) viii. p. 28 (1884).

Teratological Evidence as to the Heredity of Acquired Conditions. By BERTRAM C. A. WINDLE, M.A., M.D., Professor of Anatomy in the Queen's College, Birmingham. (Communicated by E. B. POULTON, M.A., F.R.S., F.L.S.)

[Read 7th February, 1890.]

THE subject of congenital malformations is one which, strangely enough, has met with but little notice amidst the mass of evidence which has been brought forward, on one side or the other, as to the transmissibility of acquired characters, a question which has provoked, and is provoking, so much controversy.

Yet it is certain that the consideration of the question from its teratological aspect ought to be of some service, since, in the first place, there are two groups undoubtedly amongst congenital malformations, blastogenic and somatogenic, to use Weismann's terms, though it may not always be easy to assign a given defect with certainty to either. And, again, it ought to be possible to throw some light upon the difficult question of the origin, development, and fate of a variation, from the copious mass of literature which exists in relation to teratological subjects. It seems probable that the reason why this field has been so little explored in the present connection, is that the etiological side of teratology has, up to the present, been so much neglected. Professor Cleland, who has done so much for the study of the subject in this country, has very aptly remarked that teratology should be defined as "pathological embryology." Before, however, much practical information can be gathered from the subject, it is, above all things, necessary that its classification should be arranged upon an etiological basis. The author just quoted remarks in an essay on "Teratology, Speculative and Causal, and the Classification of Abnormalities"*:—"If the advantage which biological doctrine has hitherto derived from teratology has not been great, the reason has lain, not in the barrenness of the teratological field, but in the small amount of progress made in determining the true nature of teratological phenomena. Even after the old conception of *lusus naturæ* had been thrown aside, the most imperfect notions continued to prevail

* 'Memoirs and Memoranda in Anatomy,' vol. i. 1889.

both with regard to abnormalities by excess and many of the more important abnormalities by defect. But we have now arrived at a time when no thoughtful enquirer can be longer content with merely cataloguing deviations and bestowing upon them sesquipedalian names such as were perhaps justifiable in the days of the elder St.-Hilaire. Investigation has entered upon a more strictly causal stage; and, to my thinking, it becomes evident that teratology has an important work before it in relation to biological science generally, by demonstrating the presence of potentialities which in the normal organism lie dormant, but nevertheless must exist, or they could not in exceptional circumstances show their presence."

In the present essay my intention is to examine the recorded groups of hereditary malformations, with a view to ascertain their nature, so far as may be possible, whether blastogenic or somatogenic. In order to do so, it will be necessary, however, for me to preface this portion of my paper with a short account of the groups into which malformations should be causally arranged. At the conclusion of the main part of the paper, that, namely, which deals with hereditary malformations, I shall add a few remarks on certain points in connection with the causation of malformations which have not, I think, up to the present received sufficient attention.

I may perhaps here state that this paper was not undertaken with a view either to support or to oppose Weismann's views. My desire has been to examine the subject from a teratological standpoint and to record the result of my observations.

Section I.—Varieties of Malformations.

As has been already suggested, any etiological classification of anomalies at the present time must be more or less tentative; yet I believe we may reasonably strike a line of division between two great groups, each of which may be again subdivided. The first group consists of malformations which are due to some error in the amount of formative material, and the second of those which are not. The former group may be spoken of as non-mechanical, and the latter as mechanical, provided it be understood that these terms are not used in the sense in which they are applied to the ordinary occurrences of development by His, Weismann, Roux, and other writers. Errors of material may be in two directions,

viz. excess or defect. To the former class belong double monstrosities, complete and incomplete, unilateral or partial hypertrophies, and excesses such as polydactyly (at least the majority of cases), polymastia, with others, often not recognized unless a dissection happens to be made, such as accessory carpal bones, splenculi, &c. Having discussed the sources of this excess of material in a former paper *, I shall not delay here further on that point. To use Weismann's term, malformations of this class are, with probably very few exceptions, inherent in the germ or blastogenic. Deficiency of material leads to defect of size or parts. Thus, to this group belong dwarfs and some cases of ectromelia, ectrodactyly, microphthalmus, and anophthalmus, with possibly most of the non-mechanically caused clefts, such as cleft-palate, persistent branchial cleft, and coloboma oculi. How is this deficiency of material caused? I believe in at least two ways:—(1) By faulty segmentation during the extrusion of the polar bodies, whereby too much formative material is got rid of. (2) By the very early destruction by some morbid process of early segmentation-spheres. Roux's experiments, which I have quoted in my paper already mentioned, and an account of which will also be found in a recent address by Mr. Poulton †, show that even the first few lines of segmentation cut off morphological areas the destruction of any one of which would lead to the non-development of the part which it was destined to form. It is, of course, possible that to the two preceding causes should be added that of an original paucity of material in ovum or spermatozoon prior to the extrusion of the polar bodies. The first and last causes would be inherent in the germ, and therefore blastogenic; but what of the second? Early though it occurs, it can scarcely be looked upon as other than somatogenic in its nature. The effects, however, may not be distinguishable from those due to the blastogenic causes mentioned. Here, of course, the difficulty of discrimination renders any inferences difficult and dangerous. The second great group of mechanical malformations is obviously entirely somatogenic in its nature; and the only dubious point connected with it is the difficulty of deter-

* "The Origin of Double Monstrosity," Journ. of Anat. and Phys. vol. xxiii. p. 390.

† "Theories of Heredity." An Address, reprinted from the 'Midland Naturalist,' Nov. 1889.

mining in all cases whether a given defect belongs to it or to one of the other divisions. This group may be divided into the following classes:—(1) Clefts of various kinds, due to the presence of tumours or to fluids consequent upon inflammation. Certain forms of cleft-palate belong to the former category, abdominal and spina clefts to the latter. (2) Deficiencies of extremities &c. due to inflammation of tissues leading to formation of fibrous tissue, its contraction, and the strangulation of growing parts. As examples of this may be named certain forms of peromelia and (?) atresia ani. (3) Deficiencies due to amniotic pressure. (4) Deficiencies due to adhesions of the amnion &c., including the so-called intra-uterine amputations. Having thus very briefly sketched the main lines of classification, it will be necessary in the next section, as each malformation comes up for examination, to consider at greater length and in more detail its special etiology.

Section II.—Nature of Hereditary Malformations.

In this section I purpose examining those malformations whose hereditary nature is established, *seriatim*. In connection with the etiology of each will be considered its nature, whether blastogenic or somatogenic. I shall have to draw largely from a former paper of my own "On Congenital Malformations and Heredity" *, in which are collected a number of recorded cases of such malformations, but without reference to their etiology. It will be convenient in the subsequent part of this paper to group the malformations under the classes which have been indicated in the first section.

Part 1.—*Malformations by Excess.*

The most important members of this group, all the forms, that is, of double monstrosity, have to be entirely excluded from the present inquiry. An enormous majority are non-viable, or only maintain a separate existence for a few hours or days; and the remainder are, even if married, sterile. The same remark applies, as will appear later, to most of the major and even to some of the minor forms of abnormality. We can, however, with profit examine two classes of cases not commonly grouped under the

* Proc. Birm. Phil. Soc. vol. vi. pt. 1.

head of malformations, and yet closely allied to Double Monsters, viz. Giants and Homologous Twins. According to the views expressed in the first section, a little more formative material plus equivalent division, or even the latter alone, would transform the giant into a double monster, or the latter into a pair of homologous twins. A few notes, then, upon these two groups are quite pertinent to the subject in hand.

Giants.—These are generally sterile, according to the best authorities. I. G. St.-Hilaire says of them *:—"Ils sont ordinairement impuissants, et sont très promptement énervés par les plaisirs de l'amour. Le défaut d'aptitude des géants aux fonctions génératrices ne saurait étonner chez des êtres épuisés et affaiblis par la rapidité et l'excès de leur accroissement." And in a footnote he adds, "chez quelques géants, l'érection est même presque complètement impossible." Topinard † agrees with St.-Hilaire on this point. Again, gigantic children are generally still-born when the mother is of the ordinary size. Thus, Dr. Parvin ‡ states:—"Some women, though their labours are at the normal period, give birth to children whose great development presents a more or less serious obstacle to labour, and still-births are not unfrequent." Kormann refers to a case in which the child presenting by the breech was still-born, and weighed 9·8 kilos. (normal weight 3–4 kilos.).

With regard to the frequency of occurrence of large fœtuses, Jaggard says § :—"Variations in weight at term between six and nine pounds are by no means rare—an infant over nine pounds is not common; while heavier weights are progressively rarer. Out of 1000 infants, Dr. Parvin saw but one that weighed eleven pounds (Parvin's Obstet. p. 138). Of 1156 infants born in the Maternity Hospital, the heaviest weighed 12 pounds." Giants thus resemble double monsters in rarity, non-viability, and sterility. Instances are, however, on record where giants have borne gigantic children. Mrs. Bates was 7 ft. 9 in. in height, and her husband 7 ft. 7 in. She bore him an infant which weighed $23\frac{3}{4}$ pounds (normal av. $7\frac{1}{3}$ pounds); its height was 30 inches

* 'Anomalies de l'Organisation,' vol. i. p. 183.

† 'Eléments d'Anthropologie générale,' p. 436.

‡ 'American System of Gynecology and Obstetrics,' vol. i. p. 753.

§ 'American System,' vol. i. p. 214.

(normal 20–21), breast measure 27 in., head 19 in., foot $5\frac{1}{2}$ in. The liquor amnii amounted to 5 gallons, and the secundines weighed 10 pounds. Again, the Nova-Scotia giantess, according to Harris *, bore a child which weighed $28\frac{3}{4}$ pounds. Thus giantism, if the word may be coined, is, or may be, hereditary. Moreover, as St.-Hilaire remarks, the brothers and sisters of giants are generally of large stature; they come, in fact, of tall families, to quote the popular phrase, embodying the popular belief, correct in this case, of the heredity of stature. Is this variation blastogenic or somatogenic? I have no hesitation in assigning it to the former class. If it be urged that the condition is due to the superior nourishment of the child by the mother whilst pregnant, and is therefore blastogenic, I would reply (1) that gigantic children are not necessarily the product of well-nourished mothers; for, were it so, by this time our Royal and some of our noble families ought to be like children of Anak; and (2) that giants are at birth not always larger than ordinary children. They possess the potentiality of great size, a potentiality which is, I believe, inherent in the germ. Cohnheim puts this point of the potentialities of growth so well, that I shall quote his own words †:—"Der Neugeborene bringt nicht die Geschwulst, sondern lediglich das überschüssige Zellmaterial mit auf die Welt, aus dem unter günstigen Verhältnissen später einer Geschwulst herauswachsen kann. Nur möchte ich noch einmal nachdrücklich bitten, das Sie Sich nicht zu sehr an dem Wortlaut des 'überschüssigen Zellmaterials' binden wollen; vielleicht wäre es selbst richtiger, statt dessen von demjenigen Material zu sprechen, welchem die Potenz zu späterer Geschwulstbildung beiwohnt. Denn auf diese Potenz kommt es an, die übrigens keine andere Eigenschaft ist, als wie so ungemein häufig bei der individuellen Vererbung und Entwicklung sich geltend macht. Wenn bei dem Sohn eines langnasigen Vaters die bis dahin völlig proportionirte und ganz unauffällige Nase im 8 oder 10 Lebensjahr oder noch später grosse Dimensionen annimmt und ungewöhnlich lang wird, so zweifelt Niemand daran, dass die Potenz zu diesem Wachsthum von Anfang an in der Nase existirt hat—obschon die sorgfältigste und genaueste mikroskopische Untersuchung in den ersten

* New York Med. Record.

† 'Allgemeine Pathologie,' Bd. i. S. 740.

Lebensjahren ausser Stande gewesen sein würde, jene Potenz aufzudecken."

In the same way the child-giant brings into the world with him the potentialities of his stature and size. On the other hand, it may be urged that post-natal nourishment may be the factor; and Bishop Berkeley's giant* may be cited in confirmation. To this it may be replied, that post-natal nourishment can affect the height only within very narrow limits; for otherwise there would be none but dwarfs in those parts of Ireland, for example, where potatoes and seaweed are the staple foods, and none but giants amongst the classes whose circumstances have been easy for generations past. And, as far as M'Grath is concerned, the instance is an isolated one; and there is no evidence to prove what the unfortunate man's stature might have been had he not been subjected to the episcopal tender mercies. On the whole, then, I think it may be said that giantism is an occasionally hereditary condition, blastogenic in its nature.

Homologous Twins.—It is an unfortunate circumstance that the confusion which has existed with regard to true or homologous twins and the other form, vitiates all the statistics as to twins, so far as I have examined them. True twins, which are always of the same sex, enclosed in the same membranes, generally strikingly like one another, and the product of one ovum, are of course totally different from twins the product of two ova, enclosed in separate membranes, not necessarily of the same sex, nor more alike than children of the same family are, or may be. This fact has, however, not been taken into account by those who are responsible for the statistics of twins; and it is consequently impossible to say whether the facts observed relate to both classes or only to one. Subject to this reservation, it may be said that the bearing of twins is certainly hereditary—"runs in a family," as the phrase has it. This is also true of multiple births beyond the number of two. Thus Osiander† gives a case where a woman, herself a twin, was the mother of 38 children, and died in childbed after delivery of twins. One of her daughters, who was born with three others at a birth, had 32 children at 11 confinements. The following statistics given

* 'Philosophical Survey of Ireland,' London, 1777, p. 187.

† 'Handb. d. Entbindungskunst,' 1 Th. 1 Abth. S. 319. Quoted in Edinb. Med. Journ. vol. iii. p. 1143.

by Gœhlert * are of interest in this connection. He first gives a table, from amongst the cases which he has collected, of the pairs and sexes :—

	No.	Male.	Female.	Per cent.
SIMILAR. Two males	61	122	....	29·76
,, females ..	52	....	104	25·36
DISSIMILAR	92	92	92	44·88
Total	205	214	196	100·00

In examining this table it must, of course, be remembered that the first two lines need not necessarily relate solely to homologous twins. It is quite as possible for two children, of the same sex, yet not true twins, to be born at a birth, as it is for two of different sexes. Passing to the subject of heredity in twinning, Gœhlert states that there is a direct heredity from twin to twin as well as an indirect. That this is not more observable is, he remarks, due to the fact that so many twins die in childhood, only seldom reaching maturity, and, of course, then not always bearing children. He believes that in 132 of 192 cases selected from Royal pedigrees which he carefully examined, the influence of heredity was to be observed. The figures are given in the subjoined table:

	From Father.	From Mother.	Pairs.
Direct inheritance	5	11	16
Indirect ,, ...	57	55	112
Direct and indirect	..	..	4
	62	66	132

All that can be said is, that it is at least highly probable that the production of true twins is hereditary.

I have stated that twins are not usually regarded as abnormalities; yet the two are much more closely related than is generally thought. Dr. Mitchell † shows this clearly in a paper, the conclusions drawn in which are:—(1) Among imbeciles and idiots a much larger proportion is actually found to be twin-born than among the general community. (2) Among the relatives of imbeciles and

* "Die Zwillinge," Virchow's Archiv, Bd. 76, S. 457.

† Med. Times & Gaz. Nov. 15, 1862.

idiots twinning is also found to be very frequent. (3) In families, when twinning is frequent, bodily deformities (of defect and excess) likewise occur with frequency." This last conclusion points in the direction of the blastogenic nature of twinning.

Those who hold the opinion that the mother's state of nutrition may be a potent factor, may derive some support from Dr. Matthews Duncan's conclusion, drawn from numerous statistics *, that "the largest number of twins is produced by women of from twenty-five to twenty-nine years of age †; and on each side of this climax of fertility in twins there is a gradually increasing falling-off in their number as age diminishes on the one side, and increases on the other." That nutrition has at least a large influence in the determination of sex, is a proposition supported by Geddes and Thomson ‡; and, as they appropriately ask, and the question might equally apply to the subject of twins, were nutrition proved to be a factor in its production, "How does Weismann explain the determination of sex, which illustrates an outside influence penetrating to the reproductive cells?" It may just be noted, in connection with this subject, and with the last-named authors' view that superior nutrition tends to the production of the anabolic female sex, that the larger number of twins belong to that sex. To sum up this subject, it must unfortunately be said that beyond the statement that twinning is hereditary, it is impossible, in the present chaotic state of statistics on the subject, to draw any definite conclusions in favour of either side of the argument.

Having disposed of these points, I may now proceed to the other malformations partaking of the nature of excess.

Polydactyly.—This is one of the most strongly hereditary forms of malformation. Broca § and McKellar ‖ have both recorded cases where it has passed through six generations, and Muir ¶ one through five. One of the most completely recorded cases is that by Clement Lucas, which is here reproduced (p. 457) **.

* 'Fecundity, Fertility, and Sterility' (Edinb. 1871), p. 100.

† Nutrition being probably at its best during those years.

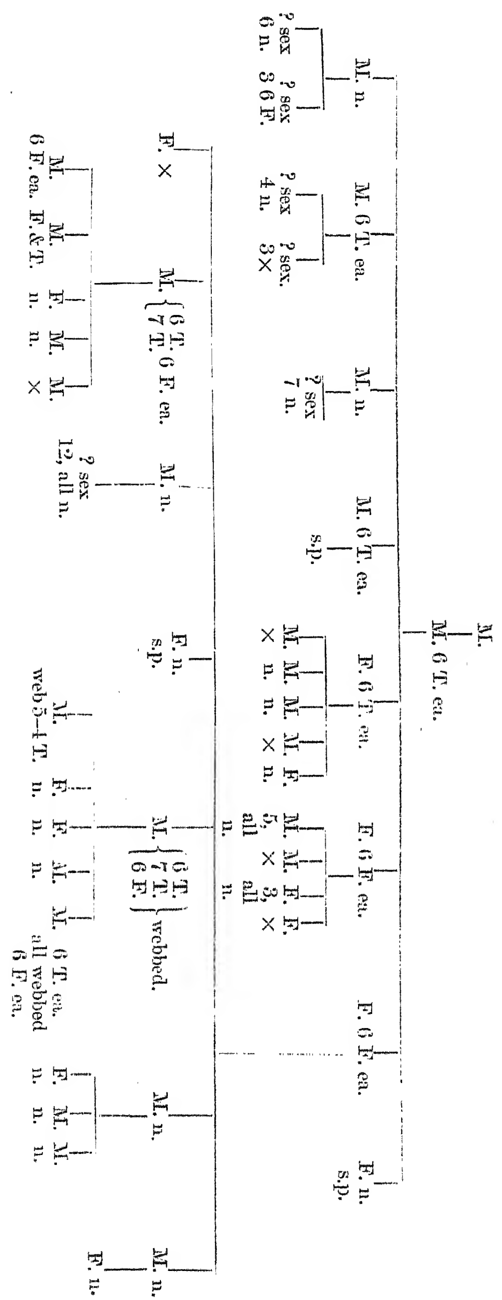
‡ 'The Evolution of Sex' (London, 1889), p. 53.

§ Acad. de Méd. Paris, quoted in Lond. Med. Rec. vol. vi. p. 91.

‖ Glasgow Med. Journ. May 1870.

¶ Ib. vol. xxi. p. 420.

** Guy's Hospital Reps. vol. xxv. Abbreviations: T.=toes; F.=fingers ea.=both members affected; s.p.=sine prole; × =affected.



It is no exaggeration to say that scores of minor cases might be cited were there any advantage in doing so *. It is more important to consider the etiology of the affection. The different forms may be classified in various ways: Gaillard †, for example, dividing by the amount of excess present, a somewhat important factor, as will appear. Thus: "1st. The finger is only bifid, articulating with the metacarpus by a single head. 2nd. Two fingers are placed in juxtaposition, being articulated side by side, only one articular capsule surrounding the head of the metacarpal bone. 3rd. Rarest: the supernumerary finger is entirely isolated, and implanted on a special articular surface of the metacarpus, the superfluous part being almost always a thumb or great toe." Or, again, superfluous fingers may be classified into marginal and central—those, that is, connected with the edge of the thumb or little finger, and those connected with some other finger. That these are different in their nature has been recently pointed out by Kollmann ‡. He says:—"Meine Rudimenttheorie nur den ulnaren und radialen Strahl (Vordaumen" [this had been previously described as præpollex by Bardeleben] "und doppelten kleinen Finger) als Hyperdaktylie verständlich machen soll; andere Arten der Hyperdaktylie gehören bis auf weiteres in das Gebiet der Teratologie. Um Missverständnissen vorzubeugen, wiederhole ich deshalb; Es giebt keine Stapedifera mit mehr als fünf Fingern, aber solche mit fünf Fingern und mit Spuren eines ulnaren und radialen Strahles (Mensch, viele Säuger, Reptilien und Batrachier). Diese Spuren liegen oft als schwer erkennbare Rudimente unter der Haut. In Fällen von Hyperdaktylie des Menschen vergrössern sich diese Rudimente und treten verschieden entwickelt aus der Haut hervor. Der Rückschlag aus diesen Rudimenten liefert wahrscheinlich stets nur Rudimente, d. i. verkümmerte Finger. Hyperdaktylie ist keine pathologische, sondern eine theromorphe § Erscheinung und weist auf eine Reduktion von Strahlen hin, welche bei der Umformung der

* For a very full list, see a paper by Dr. Fackenheim, 'Jenaische Zeitschr. für Naturwissenschaft,' Bd. xxii. N. F. xv. S. 343.

† Gaz. Méd. 1862, No. 43. Quoted by Annandale, 'Diseases of the Fingers and Toes' (Edinb. 1865), p. 26.

‡ 'Mitth. aus d. Anat. Inst. im Vesalianum zu Basel,' 1889.

§ "θήρ-θῆρος, das Thier, auch Thiermensch, φῆρ woron das lat. ferus, ferox, &c."

Fischflosse in eine Batrachierhand mit aufgenommen wurden. Hyperdaktylie des Menschen is demnach eine besondere Form des Atavismus."

As to the mesial form, there is more difficulty in deciding. According to some authorities, as, for example, Ahlfeld*, polydactyly is the result of the compression of the growing digits by amniotic bands, the depth and amount of the excess depending upon the extent of the constriction. Two points should, however, be noted in this connection:—(1) The malformations which are accounted for by pressure of the membranes or by constriction from bands derived from them, or from other sources which will be more particularly considered when the subject of peromelia is dealt with, are gradually being reduced in number as our knowledge increases. Many conditions attributed to these causes are now satisfactorily accounted for in other ways. In connection with the present subject, it may be said that there is little, if any, evidence to show that amniotic bands have ever anything to do with the production of polydactyly. (2) It is not easy to understand how a malformation caused in this way could become hereditary. The heredity, if any exist, must run in one of two lines—an heredity of the amniotic bands causing the malformation, or an heredity of a malformation first caused by a band. The first, which, by the way, has been advanced, seems too improbable to require much consideration. The coincidence by which an inflammatory band could form in exactly the same position, and produce the same effect in the pregnancies of several generations, is one which can scarcely be admitted. And the second mode would be nothing more or less than the inheritance of a mutilation. But Weismann has proved, I think it will be universally acknowledged, in his various writings, that a mutilation has at least never been shown to have been transmitted. Laying aside, however, these two considerations, we have two kinds of polydactyly—the marginal, which it is highly probable is always atavistic and blastogenic; and the central, which may be due to excess of material in the germ, and therefore blastogenic, or, possibly, to amniotic bands, and therefore somatogenic.

It is instructive, then, to inquire which of these is the most common. According to Förster, a supernumerary little finger

* 'Die Missbildungen des Menschen' (Jena, 1865), S. 43.

is the most common form, a thumb or great toe comes next in order, least commonly is the digit one of the central group. I have no data to decide whether the same rules apply to the hereditary cases; but I have little doubt that it would be found so. In the celebrated case quoted by Devay *, where the hereditary malformation was more widely spread within a circumscribed area than in any other with which I am acquainted, the supernumerary digit appears to have been a thumb. I think that this case is worth describing in detail. "Il s'agit d'une véritable endémie de *sexdigitisme*, d'une population entière qui . . . . a été frappée de cette bizarre anomalie. Nous devons la connaissance de ce fait singulier à notre savant confrère, le docteur A. Potton, qui l'a observé sur les lieux mêmes. Il existe dans le département de l'Isère, non loin de la Côte-Saint-André et de Rives, un tout petit village nommé Izeaux, isolé, perdu en quelque sorte autrefois, au milieu d'une plaine, si non complètement inculte, du moins très-pauvre, dite la plaine de Bièvre. Les chemins, les communications dans ce pays peu fertile, étaient difficiles, si non impracticables. Les habitants d'Izeaux, simples, presque abandonnés à eux-mêmes, n'entretenaient que des rapports éloignés avec les populations environnantes, sans se mélanger avec elles; ils se mariaient constamment entre eux, et ainsi fréquemment en famille. A la fin du siècle dernier, de cette manière de faire, de ces alliances constantes entre parents était née et entretenue par elle une monstruosité singulière, qui, il y a trente-cinq à quarante ans, frappait encore presque toute la population. Dans cette commune, hommes et femmes étaient porteurs d'un sixième doigt, d'un doigt supplémentaire implanté aux pieds et aux mains. 'Lorsqu'en 1829 et en 1836,' dit M. Potton, 'j'ai observé ce bizarre phénomène, déjà, chez quelques sujets, il n'existait qu'à un état plus ou moins rudimentaire; chez plusieurs, ce n'était qu'un gros tubercule, au centre duquel cependant on rencontrait un corps dur, osseux; l'apparence d'un ongle plus ou moins formé terminait cet appendice, fixé latéralement en dehors, *à la base du pouce*†. La personne qui m'accompagnait, bien qu'étrangère à la médecine, me faisait observer qu'une heureuse transformation tendait à s'opérer, que de notables changements dans cette défectuosité organique s'étaient établis depuis que les habitudes de la population s'étaient modifiées par la force des

* 'Du Dangers des Mariages Consanguins' (Paris, 1862), p. 95.

† Italics mine.

choses, par le progrès, depuis que, les voies de communications étant devenues meilleures, les rélations à l'extérieur plus fréquentes, les alliances se contractaient dans des conditions plus favorables; depuis, en un mot, que le croisement des races avait lieu. En 1847 j'ai eu occasion de voir un chef d'atelier, originaire de cet localité, fixé et marié à Lyon. Il était porteur du vice de conformation signalé; il était père de quatre enfants, qui n'avaient point le stigmate paternale. A l'heure qu'il est, d'après les renseignements circonstanciés pris auprès de médecins de la localité, cette anomalie pathologique a presque complètement disparu.' "

To sum up, then, the subject of polydactyly, it may at least be said that there is no proof that any of the hereditary cases are somatogenic. I should go further myself, and say that there is every reason to believe that they are blastogenic.

Supratrochlear Process.—Struthers * has recorded a case in which this curious process or hook was hereditary. It is atavistic and undoubtedly blastogenic in its nature.

Polymastia.— Accessory breasts may exist on the thigh, groin, vulva, back, or other parts of the body, the following table giving Leichtenstern's † figures from an examination of 105 cases :—

The accessory gland was		on the anterior surface of the thorax		in	96.
,,	,,	in the axilla	,,	,,	5.
,,	,,	on the back	,,	,,	2.
,,	,,	on the acromion	,,	,,	1.
,,	,,	on the thigh	,,	,,	1.

The condition may be hereditary, as in the case narrated by Robert ‡ of a woman who had a third breast on the exterior of the left thigh placed 4 inches below the great trochanter, with which she had suckled several children; her mother had a third thoracic breast. Woodman § records a case where a woman and her child were both possessed of three thoracic mammæ. As to the cause of the malformation, one would not think that there need be much difference of opinion. Ahlfeld ||, however,

* Lancet, Feb. 15, 1873.

† Virchow's Archiv, Bd. 73, S. 222.

‡ Journal de Physiologie, tome vii. no. 2.

§ Trans. Obst. Soc. vol. ix. p. 50.

|| 'Die Missbild. d. Menschen' (Leipzig, 1880), S. 110.

has committed himself to the statement that they are due to the action of the amnion. "Am wahrscheinlichsten ist mir die Möglichkeit, dass durch den Druck des Amnions Theile abgetrennt und am Amnion haftend auf der Körper Oberfläche transplantirt werden." The author just quoted is, I am convinced, mistaken in pushing his views as to the malformation-producing capacities of the amnion so far as this. There can be little doubt that the malformation is atavistic. The English edition of Wiedersheim's 'Comparative Anatomy' * contains the following statement on the subject:—"The occasional existence in men of supernumerary teats and in women of supernumerary teats and mammæ (polythelism and polymastism) is very remarkable. They are usually situated in the thoracic region, and must be considered as an atavism to a characteristic primitive form which possessed numerous teats, and which produced a number of young at a birth. Such a transition from polymastism to bimastism may be seen plainly at the present day in the Lemurs; in them the inguinal and abdominal teats are undergoing a retrogressive metamorphosis, while a single pair of thoracic teats remain well developed. [In *Hapalemur griseus* the single pair of teats is situated on the arm (*Beddard*).] This accords with the fact that most Lemurs bear only a pair of young ones at a time, which they carry with them at the breast." In this connection it is interesting to note that, as Dr. Champneys has shown †, the skin of pregnant women may take on mammary functions in isolated spots, lumps forming in various places, notably in the axilla, from which come (*a*) granular débris like the secretion of sebaceous follicles; (*b*) colustrum; (*c*) milk, expressed from the situation of the sebaceous follicles, as marked by the position of the hairs. These cases show, he says, "that in lying-in women the sebaceous follicles of the skin are capable of producing true mammary secretion. The transition from granular material, through colustrum, to true milk is unmistakable." The observations confirm the opinion that the breast is a highly specialized aggregation of highly specialized sebaceous follicles.

The facts which have just been reviewed leave little room for doubt that accessory mammæ are atavistic and blastogenic.

Hypertrichosis.—Excessive hairiness, which appears to be usually associated with deficient dentition, is an occasionally

* P. 28. † Roy. Med. & Chir. Soc., April 27, 1886.

hereditary condition. Cases of this nature have been recorded by Darwin * and Michelson †. That of Andrian Jeftichew and his son Fedor (*æt.* 3 at the age of description), both of whom had their faces covered with hair "like Skye-terriers," and were nearly edentulous, is a good example ‡. The possibility of this condition having a nervous origin will be discussed in a subsequent section. It is probably atavistic and blastogenic.

Gluteal Protuberances.—The excessive development of the gluteal region amongst the Hottentot women and of their nymphæ may here be mentioned as examples of malformations which have risen to the rank of racial characteristics. They are, apparently, blastogenic in their nature.

In concluding the portion of this paper relating to malformations by excess, the speculation may be permitted as to whether there may not be many hidden abnormalities which are highly hereditary yet which escape notice. Take, for example, the instance of a centrale carpi. One would expect that this abnormality would be hereditary, and possibly it is so; but we have no data to go upon, and in this instance it is not probable that we ever shall have. In other cases, however, a little trouble on the part of the observer might enable many gaps to be filled up. As an example of what I am alluding to, I may cite a curious case, the only one known to me of a described hereditary abnormality in the arterial system, though it is probably by no means an isolated case, were the question to be carefully investigated §. The radial artery in a male, on both sides passed over the supinator longus at from 3·0 cm. to 4·0 cm. above the wrist, and ran over the radial extensors above the styloid process to its normal distribution. All this man's children possessed the same abnormality on the left side, the daughters transmitted it better than the sons, and amongst the grandchildren it was met with on both sides on four, on one side only in four, and was absent in seven.

Part 2.—*Malformations by Defect.*

In this section the malformations by defect will be discussed, and at the outset it may be said that their etiologies in many

* 'Animals and Plants under Domestication,' vol. ii. p. 320.

† "Zum Capitel der Hypertrichosis." Virchow's Arch. Bd. 100, S. 66.

‡ Lancet, 1873, ii. p. 613; and Virchow, Berl. Klin. Woch. 1873, No. 29.

§ Chicago Med. Journ. & Exam. 1879, p. 475.

cases offer much greater difficulties than those of the group just concluded.

Dwarfs.—The arguments which were used to show that giantism was a blastogenic condition due to excess of formative material, might, in converse, be employed to prove that dwarfishness is blastogenic and due to deficiency of material. As with giants, so with dwarfs, sterility is the rule. In their case, we have on this point even better evidence than in that of giants, since dwarfs have been made the subject of direct experiment. "Cathérine de Médecis s'amusa, dit on, à rassembler des nains des deux sexes et à les marier. L'électeur de Brandenbourg répéta la même expérience; ils n'eurent pas d'enfants. Geoffroy St.-Hilaire ne découvre qu'une seule exception, celle du nain Borivilaski; mais sa femme était de taille ordinaire et fut suspectée" *. Though sterility is the rule, yet there are indications of hereditary influence in this group also.

Thus, as St.-Hilaire points out †, in the greater number of cases the same mother has given birth to two or more dwarfs, amongst the cases he cites being that of the dwarf brother and sister described by Aldrovandus ‡. I have also met with an account of one case where dwarfishness was distinctly hereditary §. Francesco Leporatá, born of full-sized parents, was at the age of 83, 1·130 mtr. He had married a full-sized woman and had issue at the time of enquiry:—(1) *Doralice* (F.), æt. 50, height 1·130 mtr.; (2) *Anna*, æt. 41, height 0·980 mtr.; (3) *Maria*, æt. 31, height 1·155 mtr.; (4) *Maddalena*, æt. 34, of normal height; (5) *Antonio*, æt. 44, height 1·340 mtr.; (6) *Pietro*, æt. 42, height 1·300 mtr. Antonio (5) married twice. His first wife, who was of full size, bore him a normal-sized daughter; his second, also a full-sized woman, bore him three sons:—(*a*) æt. 14, height 0·945 mtr. (normal for age, 1·49 mtr.); (*b*) æt. 9, height 0·970 mtr. (normal, 1·219 mtr.); (*c*) æt. 7, height 0·910 mtr. (normal 1·106 mtr.). Pietro (6) married a full-sized female, and had issue—(*a*) M. æt. 6, height 0·825 mtr. (normal 1·046 mtr.); (*b*) F. æt. 3, height 0·650 mtr. (normal 0·864 mtr.); (*c*) M. æt. 1½, height 0·616 mtr. (normal 0·744 mtr.).

* Topinard, *op. cit.* p. 436.

† *Op. cit.* p. 159.

‡ 'Monstrorum Historia,' pp. 603 & 604.

§ Quoted from Ludwig Frank, Mem. della R. Accad. di Torino, t. 25. p. 96 (Torino, 1820), by Taruffi, Riv. Clin. 2 ser. viii. p. 33; Abstr. Schmidt's Jahrb. t. 198. S. 8.

Absence of Bones or Parts of Bones.—Malformations of this kind are not very uncommon. In the following, amongst other cases, the condition has been hereditary:—(1) Prof. Sir Wm. Turner has described * a case of shortening of the ring-finger, which was 1·2 in. shorter than the middle, and only 0·5 in. longer than the little finger. This condition was not due to absence of any of the bones, but to imperfect growth of the metacarpal bone. In the family was also present widening of the great toe and thumb—sometimes with short ring-finger, sometimes without. The malformation ran through six, or possibly seven, generations. (2) In another family † shortening, due to absence of phalanges, in a variable number of digits ran through three, or possibly four, generations. (3) Absence of patellæ through two ‡ and three § generations has been recorded. (4) Imperfection of one or other end of one or both clavicles has existed through three generations in a family ‖. There can be little doubt that these malformations are blastogenic, and due to deficiency of formative material.

Peromelia and Perodactyly.—Absence of parts or of an entire limb or digits. This group opens up the whole question of intra-uterine amputations, which requires some little consideration. First described by Montgomery ¶, it has been discussed by a number of later writers, some of whose opinions must here be dealt with. In Montgomery's first case the foot which had been amputated was found in the membranes, and was apparently two months younger than the child to whom it belonged. In another case the constriction had severed everything but skin and bone. According to his view inflammatory lymph was thrown out, which constricted the growing part and effected the amputation. Dr. Macan ** has described a case of amputation of the arm below the insertion of the biceps, in which the cicatrix was quite healed. The amputated part was not found, though searched for. In 30 years only one case of intra-uterine amputation had been recorded in the practice of the Rotunda Hospital, Dublin. In the discussion which followed upon the paper in which this case was described, Dr. Kidd said that in something less than 30 years he had seen

* Journ. Anat. & Phys. vol. xviii. p. 463.

† Tilley.

‡ Med. Notes and Reflections, p. 33.

§ Med. Gaz. 1833, p. 519.

‖ Warren Museum Catalogue, no. 217.

¶ In an Essay "On the Spontaneous Amputation of the Fœtal Limbs in Utero," at the end of his "Signs and Symptoms of Pregnancy."

** Dubl. Journ. Med. Sci. vol. lix. p. 55.

four cases. In one of these, the leg was amputated between the knee and the ankle, the severed portion being found in the membranes. Other bands had nearly amputated some of the fingers. According to Hennig *, the substance which forms the bands may be formed sometimes from the skin of the embryo, sometimes from the membranes, and sometimes from both. The skin alone was, in his opinion, the cause in most of the recorded examples of spontaneous amputation. Before considering what proportion of the cases of defective limbs and digits may be due to this cause, it will be necessary to consider two special classes of cases. (1) Cases of perodactyly with absence of a forearm-bone and carpal bone. I have described † an instance where radius, scaphoid, trapezium, and thumb were all absent on both sides. It is obvious that cases such as this could not be produced by amniotic causes, but are due to absence of formative material and blastogenic in their nature. (2) There is a curious group of cases where on the end of the stump are to be found fingers generally in an imperfect state of development. Or there may be a want of the intermediate parts in the extremities so that the hand is attached immediately to the shoulder and the foot to the hip, as in the remarkable case of Marco Catonze, figured by Vrolik ‡ and Förster §. Simpson ||, in 1841, noticed what he called a tendency to rudimentary reproduction of the amputated members on the face of the stump. This he compared with the cases of reproduction of limbs in lower animals. Sturge ¶ describes an interesting case of a man aged 22, in whom the radius and ulna on the left side ended in a conical stump 3 in. below the elbow-joint. On the flexor aspect of the stump, and situated transversely across it, were five little projections, the one nearest to the radial side being the largest and the remainder gradually decreasing to that on the ulnar border; the largest and the adjoining one had well-marked nails. The author's remarks upon the subject will be more appositely quoted somewhat later. The point is a very interesting one and by no means clear, but it may be doubted whether there is really any truth in the restoration theory, and whether the facts are not much better explained by some such hypothesis as that offered

* "Ueb. d. Nebenbänder u. Schafhautstränge in der Eihohle d. Mensch.," Virchow's Arch. Bd. xix. S. 200.

† Anat. Anzeiger, Jahrg. 3. S. 63.

‡ Art. "Teratology," Todd's Cycl. of Anat. & Phys. figs. 624, 625.

§ *Op. cit.* Taf. xi. figs. 6 & 7.

|| Selected Obstetric Works, p. 129.

¶ Trans. Path. Soc. vol. xxxi. p. 208.

by the last-named writer, when he says "they [*i. e.* the imperfect digits] represent the amount of vitality left in the embryonic cells from which the extremities of the limb should have developed." We explain the presence of extremities on sacral tumours representing an imperfect parasitic twin, such as those of Anna Maria Przesomyl and the other given by Braune *, by supposing that the cells forming that portion of the limb have come to development, whilst others have failed to do so; and there seems no reason why a similar explanation should not be given in the cases under consideration. Passing from these special groups, it may next be mentioned that Erlich † has grouped congenital defects of extremities into the following divisions:—(1) deficiency of formative material (Anlagekeim); (2) deficiency of division or segmentation (Gliederung) where a ray (Tibia, Radius, with tarsals or carpals, &c.) is absent; (3) deficiency of growth from injury to cartilage or bone, Fœtal Rachitis; (4) spontaneous amputation, or strangulation.

We have now to consider the bearing of the facts just detailed upon the section of the subject now under discussion. First of all we may dismiss, I think, the subject of peromelia, since I am not aware that it has ever been described as hereditary in man. St.-Hilaire ‡ has given an account of one case in which it was hereditary in dogs, and I know of no other of any kind. Perodactyly is, however, not uncommonly hereditary. In a case given by Fotherby §, the hands and feet were both affected, only great and little toes being present in the latter; the malformation ran through five generations. Other cases have been given by Holmgren ||, five generations; Krabbe ¶, three; and Lucas, four **.

In considering the nature of this defect it should be borne in mind that there are several preliminary conditions, so to speak, leading up to it and often merging into or blending with it, none of which could be caused by amniotic agencies. Thus Annandale gives the following degrees of union of digits, a condition

* 'Die Doppelbild. u. angeb. Geschw. d. Kreuzbeingegend,' Leipzig, 1862, Taf. iii. figs. 1, 2, 3, & 7.

† "Untersuch. üb. d. Cong.-Def. u. Hemmungsbild d. Extrem.," Virch. Arch. Bd. 100. S. 107.

‡ *Op. cit.* vol. ii. p. 570.

§ Brit. Med. Journ. May 22, 1886.

|| Upsala läkarefören. förhandl. xvii. 7 og 8, S. 513; Abstr Schmidt's Jahrb. Bd. 196. S. 121.

¶ Nord. Med. Ark. xii. 20. S. 1; Abstr. Schmidt's Jahrb. Bd. 196. S. 121.

** Traité de l'Hérédité Naturelle (Paris, 1847), p. 198.

recognized as leading up to perodactyly *:—"Two or more digits may be united—(1) by loose folds of skin only (the true webbed condition) †; (2) by a more intimate connection of the skin and deeper soft tissues; (3) by the union or fusion of the bones as well as the soft textures. Besides these forms of union, the digits of one hand or foot, or of both hands and feet, may be all massed together into one lump, so that it may be almost impossible to distinguish the individual fingers or toes." This gradation of defects, the minor ones being of a kind not assignable to amniotic agencies, is the first point in favour of the blastogenic nature of the defect. A second is the nature of the defect itself. Whoever will take the trouble to examine the figures in Förster (Taf. xii. figs. 1–21) will not have much difficulty, I think, in deciding that they are highly unlikely to have been due to amniotic agencies. Many of the absent digits are central, yet these are surely more likely to escape entanglement in loops of fibrin than the marginal, which so frequently remain as the sole representatives. I may here quote *in extenso* Sturge's remarks to which I have before alluded. Speaking of his case, which he looks upon as one of intra-uterine amputation, he says:—"The congenital deficiency may also be due to (1) a primary inherent abnormal condition of the ovum whereby its healthy development is interfered with in one or more directions; or (2) a localized morbid condition of one or more parts of the embryo at some time after conception. The former of the two conditions must be invoked in explanation of many cases of monstrosity, in cases where there is congenital hypertrophy of parts, and it is the most probable explanation of supernumerary parts. There can, therefore, be no reason why it should not produce the opposite condition, viz. congenital atrophy of limbs and congenital absence of portions of limbs. On the other hand, an inflammatory condition capable of throwing out organized lymph in sufficient quantity to produce intra-uterine amputation is quite as likely, if it attacks that portion of the blastoderm from which a limb is developed, to kill the delicate embryonic cells, or to modify their nutrition so profoundly that their subsequent development will be gravely compromised. I think it is worthy of inquiry whether rudimentary fingers have been present in any of those cases where the amputated limb has been

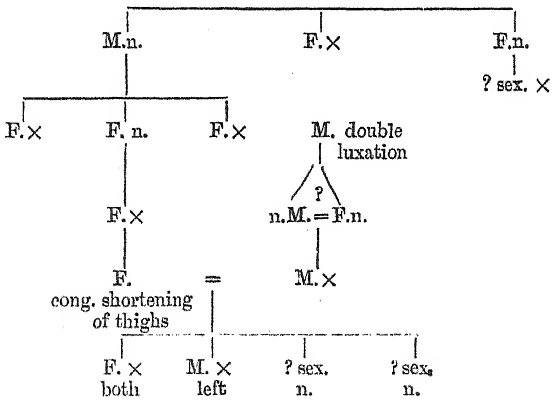
* *Op. cit.* p. 46.

† This may be hereditary. It has been described as passing through four generations. Edinb. Med. Journ. 1858–9, p 501.

found. It is very easy to account for them on the hypothesis of mal-development, for in that case they represent the amount of vitality left in the embryonic cells from which the limb should have developed. On this hypothesis, we should expect to find, as in fact have been found, many degrees of development ranging from minute nodules, representing fingers at one end of the scale, up to extremities of limbs which differ but little from the hand at the other end."

To conclude this group, without excluding the possibility of cases of perodactyly, originally caused by amniotic bands being hereditary, since there are no data for such a denial, it appears to me, for the reasons given above as well as from those which were brought forward when dealing with the subject of polydactyly and amniotic bands, that on the whole it is far more probable that perodactyly is nearly always due to defect of material, and is therefore blastogenic.

Congenital Luxation of the Femur.—This is a condition which requires some consideration, since it is certainly at times hereditary and since its origin has been very diversely explained by different writers. I append the following hereditary case, doubly remarkable since present on both sides of the house *:—



Professor Bennett, in an address on this subject†, enumerates the following opinions which have been expressed as to its cause. Dupuytren considered it to be due to an original fault of the germ, which, as Bennett says, is "sufficiently vague." Stromeyer attributed it to a disproportion between the head of

* Quoted by Dupuytren from Massiat, Med. Gaz. 1833, ii. p. 570.

† Dubl. Med. Journ. lxxix. p. 11.

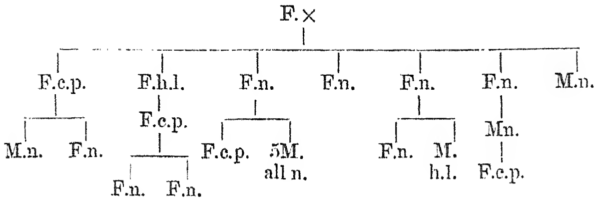
the femur and the acetabulum, Cruveilhier and Chelius to the position of the fœtus *in utero* or to violence in delivery, Ammon to arrest of development, Guerin to irregular nervous action, and South to an abnormal method of delivery. Recent writers, he proceeds, have assumed that the last-mentioned cause is always the correct one. This, however, is not the case; the specimen which he himself dissected was perfectly normally delivered by a head presentation. Other observations point to the fact that one of the causes, if not the chief cause, is a failure of development of the acetabulum due to a lack of material. Shaw, describing a living specimen, states that on digital examination, "a projecting irregularly shaped surface, supposed to be the imperfectly-developed acetabulum, was felt" *. Shepherd † has described a case which he had the opportunity of dissecting. The female, aged about 50, had the right leg smaller and shorter than the left. The wing of the right ilium was thinner, more upright, more curled inwards, and smaller. The acetabulum was a mere triangular depression in the bone with its apex directed upwards and to the right and its base corresponding to the cotyloid notch. The edges of this triangular depression were smooth and curled inwards and but slightly covered with fibro-cartilage. Its measurements were 2 in. long, $\frac{3}{4}$ in. broad, $\frac{1}{2}$ in. deep. Grawitz ‡, in a paper on the subject, refers the malformation to a failure of development of the Y-shaped cartilage. In twelve cases which he examined, there was no trace of any inflammation of the joint as the cause. Whilst believing that a defect of development is the chief cause, the possibility of irregular or excessive nervous action being also a factor must not be overlooked, since the improper action of the muscles arising from it may induce the displacement of the head of the femur from the imperfectly developed acetabular cavity. The defect will, if due to defective development, be probably blastogenic in its nature. There is, however, just the possibility that mal-nutrition of the fœtus *in utero* may be the cause. This is a large subject, which will receive the attention it deserves in a separate and subsequent section.

* Trans. Path. Soc. xvii. p. 206. The author remarks that it has never been explained why the malformation should so often affect both acetabula and occur more frequently in females.

† Journ. of Anat. & Phys. vol. xiv. p. 368.

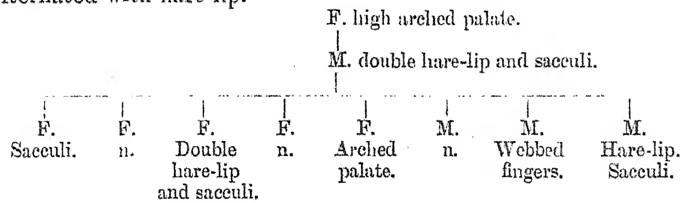
‡ "Ueber die Ursachen der angebornen Hüftgelenkverrenkungen," Virch. Arch. Bd. 74. S. 1 (1878).

Cleft-Palate and Hare-Lip.—These malformations are undoubtedly hereditary. Fritzsche found the factor of heredity to exist in five out of fifty-two cases coming under notice in the Zurich Klinik in ten years *. Mason † has recorded others, and Biondi ‡ gives the following table from Passavant §:—



(h.l.=hare lip; c.p.=cleft palate.)

I have mentioned these numerous cases since Förster and others have inclined to the opinion that cleft-palate is not hereditary. Before leaving the question of heredity in connection with these defects, it should be mentioned that the parents, if not affected with the lesion itself, may present minor malformations tending in that direction. Thus Mason (p. 18) says:—"Sir William Ferguson used to look for, and generally find, a partial defect in the upper lip and jaw of one or both of the parents, and since he directed my attention to this point, I have observed it in many instances." Again, Knaggs ||, in a report of 660 midwifery cases conducted in Australia, describes one of exaggerated hare-lip and cleft-palate, in which several individuals on the mother's side were similarly affected. Moreover, "the mother possessed a very high-arched palate, so much so as to create the impression that she had narrowly escaped the deformity itself." Finally, Murray ¶ has placed on record a case in which other malformations of the same region co-existed with or alternated with hare-lip.



* 'Missbild. d. Gesichts.' (Zürich, 1878), p. 6.

† 'On Hare-Lip and Cleft-Palate' (Lond. 1877), pp. 21 & 64.

‡ "Lippenspalte," Virch. Arch. Bd. 91. S. 173. § Arch. f. Heilk. 1862, p. 305.

|| Dubl. Med. Journ. lxxi. p. 431. ¶ Med.-Chir. Rev. vol. xxvi. p. 502

When we come to inquire into the causation of these defects, we find various theories given to account for them. Virchow *, writing of branchial and other clefts, says that without particularizing whether traumatic, thermic, or other causes act, the main fact is that the defects arise from an irritative process. Some may call this inflammatory; in any case it is not passive but active. Some forms of palatine and facial clefts have, he thinks, a similar origin in an early inflammation. It should be mentioned that this was written as long ago as 1855, and that the theory which accounts for many defects by fœtal inflammation has lost much ground since then. The defect may be due to deficiency of material, and this again, it seems possible, may be due to mal-nutrition by the mother. I quote the following passage from Oakley Coles's interesting chapter on the etiology of cleft-palate, to which I shall have to recur in a later section †:—"Dr. Ogle has called attention to the fact that 99 per cent. of the lion-cubs born in the London Zoological Gardens have cleft-palates, and he has referred this curious phenomenon to the artificial diet necessitated by the enforced captivity. It has, indeed, been contended, in reply to this theory, that the experience of the London Zoological Society is exceptional, differing from that of other menageries, and Mr. Pollock ‡ has suggested that we must seek for the cause of the phenomenon amongst other conditions than the food-supply. It is true that among the lion-cubs born in the Dublin Gardens, cleft-palate is seldom noticed; but it is stated that it used to occur quite as frequently as in London, when the feeding was conducted in a similar way, viz. by supplying only the meat of large animals. Now, however, that the lions are given goat twice a week, which they can eat bones and all, the proportion of cleft-palate has become quite insignificant. These observations seem to point to the possibility of cleft-palate in the human subject being due to an analogous departure from a natural diet amongst civilized nations, but it is at all times perilous to argue from the lower animals to man. At any rate the evidence at present before us does not admit of anything more than conjecture." If the in-

* "Ueb. Missbild am Ohr u. im Bereiche des erstens Kiemenbogens," Virch. Arch. Bd. 30. p. 221.

† 'Deformities of the Mouth' (Lond. 1887), p. 37.

‡ Holmes's System of Surgery, vol. iv. p. 420.

flammatory theory or that of mal-nutrition be true, the condition would be somatogenic in its nature. Those cases where the cleft is due to the presence of a tumour are undoubtedly so, but they are, I believe, never hereditary. On the other hand, cases due to an original lack of formative material would be somatogenic. It is possible that these and some other defects may be due to a hitherto little recognized cause, that is a failure of nerve-action during intra-uterine life. I purpose devoting a section at a later part of this paper to the consideration of this hypothesis. For the present, however, the subject of cleft-palate must be left in a highly undecided state.

Edentulism.—Partial absence of teeth, accompanied or unaccompanied by peculiarities of the hair, is an hereditary condition at times. Cases have been given by Darwin and others, and my friend Mr. Humphreys was good enough to supply me with notes of some observed by himself, which I published in my paper on "Congenital Malformations and Heredity." One very curious case communicated to me by Dr. Fackenheim, of Eisenach, and since published in his paper already quoted, I shall give at length, because of its bearing upon the question of mal-nutrition as a cause of defects, which has yet to be dealt with. In the case I allude to there is on the father's side polydactylism both of the hands and feet, on the mother's anomalous dentition. The mother's genealogy, and the children born of her union with the polydactylous Heinzler, stands as follows:—

Katharina ×

Xaver	Marie (M.)	Celestine (M.)	Kunigunde (M.)	Theresa (M.)	Appolonia	Mathilde
(unm.) ×	— × (children normal)	× Alfons ×	(children normal).	(children normal).	(unm.)	‖ Heinzler (polydactylous).

Friedrich	Frieda	Adolf	Mathilde	Elsa	August
×	×				× (?)

Katharina, the grandmother, had only two upper pointed teeth in place of the incisors, and two molars. Her children were situated, as regards their teeth, as follows:—Xaver, unmarried, is somewhat similar to his mother, so is Marie, who has normal children. Celestine is similarly affected, and so is her son Alfons, who possesses only four teeth including one first

molar. Kunigunde and Theresa, as also their children, have the normal dentition; so also has Appolonia, who is unmarried. Mathilde has six exceedingly large and pointed teeth like canines, with wide gaps between, which represent the incisors, the remainder of her dentition being normal. Mathilde married Heinzler, in whose family polydactylism is hereditary. Of their children, Friedrich (æt. 11) has the most singular dentition of his generation. The lower incisors are in his case completely absent; in place of the upper incisors are two conical teeth. The remaining teeth are normally formed. The alveolar border of the inferior maxilla is thin and defective in the situation of the defective teeth. This is less marked in the superior maxilla. There is no trace of a frænum linguæ, but otherwise the mouth is quite normally formed. It should be noted that these teeth belong to the milk-dentition, no permanent teeth having appeared. The defect is already commencing to exercise a marked effect upon the contour of the face, and undoubtedly influences the speech. The sister Frieda (æt. 14) is not quite so deficient as her brother, but the separate teeth are not so well formed as his. Like the brother, she still possesses her milk-dentition. In the upper jaw, in place of the incisors, are two pointed or crescentic teeth with their apices towards the middle line. In the lower jaw the incisors are replaced by three irregularly conical teeth, the central one being somewhat behind the other two. The remaining teeth are fairly normal, but have considerable gaps between them. There is a very small frænum linguæ, but no other oral abnormality. In both children the teeth made their appearance at the proper time. Both of these children inherit also the polydactylism of the father. They are thoroughly healthy, have never suffered from any severe illness, and have no abnormal condition of the hair. The alveolar processes of the youngest child, August, are thin, from which the mother, reasoning from what she saw in the other children, confidently asserts that he also will exhibit similar abnormalities. Dr. Fackenheim finally points out that the rudimentary condition of the alveolar processes in these children renders it impossible that the missing teeth are retained in the jaw. No one, so far as I am aware, has ever advanced the theory that defect in the number of teeth in a parent, due to the labours of the dentist, can be transmitted to the children. The fact that this experi-

ment, tried upon so large a scale, returns a negative reply is indeed to my mind one of the best arguments against the transmissibility of mutilations. There can be little doubt that the recorded cases of congenital and hereditary edentulism (congenital in the sense of the impotentiality being so) are blastogenic in their nature.

Microphthalmus.—This is the first of a group of malformations relating to the eye. In dealing with them, I have to express my obligations to my friend Mr. Priestley Smith, whose extensive knowledge of ophthalmological subjects has supplied my deficiencies in that direction. Microphthalmus is an hereditary disease—Sedgwick * narrating a case where it was hereditary on the maternal side and deaf-mutism on the paternal, both defects co-existing in some of the unfortunate descendants. It is extremely interesting in this connection to see how opinion as to the cause of microphthalmus has changed of late. It was thought by some authorities, for example Deutschmann †, that a fœtal inflammation was the cause. Were this true the condition would be somatogenic. Quite recently, however, Hess ‡, after a very careful examination of six microphthalmic eyes, has concluded :—(1) that there was no sign of past or present inflammation to be discovered; (2) that a union existed between the vitreous and the outer tunics of the secondary optic vesicle effected by means of a tissue nourished by the hyaline artery or a representative of that vessel. He goes on to state that he cannot regard this as being in any way an inflammatory product, but considers it to be the result of an atypical embryonic development of the intruded mesoblastic layer which goes to form the vitreous. He refers to other published cases which resembled his in important respects, and to which he is inclined to attribute a similar causation. The connective-tissue band formed in these microphthalmic eyes may possibly be related to the funiculus scleræ, described by Hannover and shown by Rotholz to be the permanent representative of a structure existing in fœtal life. Should these observations be correct, as seems highly probable, the malformation is a blastogenic one, though it is perhaps somewhat doubtful as to which class it should be referred to.

* Med.-Chir. Rev. vol. xxviii. p. 205.

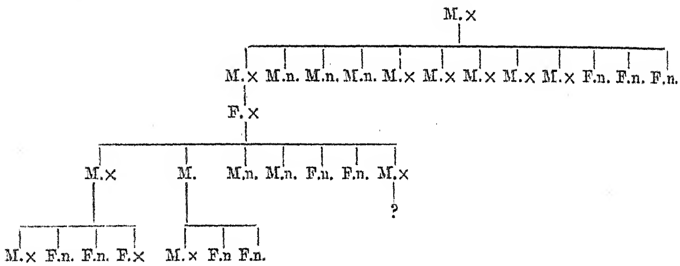
† Klin. Monatsbl. f. Augenheilk., March 1881.

‡ v. Graefe's Arch. f. Ophthalm. xxiv. 3.

Absence of Iris.—Page * has recorded a case where this condition, combined with microphthalmus and nystagmus, existed in a mother, two daughters, and a grand-daughter, two sons and a daughter having escaped. Sedgwick † quotes another where absence of iris ran through three generations. There can be no doubt that this is a blastogenic condition.

Coloboma.—A failure to close completely on the part of the choroidal fissure, doubtless blastogenic in its nature, though whether due to defect of material or to a nervous cause is not certain. It is hereditary, and Darwin ‡ has given a case where it passed through four generations.

Congenital Dislocation of the Lens.—I give here a table, drawn up by Stanford Morton §, where this curious condition was hereditary.



This defect "is sometimes associated with coloboma of the choroid or optic disc, sometimes with persistent hyaloid artery; more frequently it is met with in eyes which appear otherwise healthy. A partial lateral displacement indicates a faulty development of the suspensory ligament, by reason of which the traction upon the lens is unequal at different parts of its circumference. The displacement is usually upwards or upwards and outwards, indicating a defect in the lower part of the ligament, analogous to an imperfect closure of the fœtal slit. It is usually present in both eyes, and is symmetrical or nearly so in the two. It has frequently been met with in several members of one family and in successive generations" ‖. The defect from this appears to be one of deficient development, blastogenic in its nature.

* Lancet, Aug. 8, 1874. † From Ammon's Zeitschr., vol. i. no. 4.

‡ *Op. cit.* vol. i. p. 454. § Oph. Hosp. Reps. ix. 435.

‖ P. Smith, in Heath's Dict. of Pract. Surg., Art. "Crystalline Lens."

Strabismus.—Squint is sometimes hereditary, though Mr. Priestley Smith tells me very rarely. Portal *, in his "Considerations sur les Maladies de Famille," describes an imperfect form, called the Montmorency sight, with which nearly all the members of that family were affected. In speaking of squint, it must be very carefully borne in mind that the only true congenital cases are those which are noticed instantly after birth. This sounds like a truism, but it is a very necessary caution, since there are many cases noticed, not at birth, but within the first few weeks of infancy, which are called, incorrectly, congenital. These last-mentioned cases are secondary in their nature and follow upon hypermetropia, which is very commonly hereditary. As regards the true hereditary cases, Welcker and Landolt † remark that they probably result always from some lesion of the nerve-centres or of the motor-oculi nerve in intra-uterine life. The muscles corresponding are then rudimentary or present abnormal insertions, as in a case recorded by M. Henck, who had the opportunity of making an autopsy on a child thus affected ‡. I am informed, I should say, that the question as to whether the muscles are really shortened in this affection, is one which is much disputed by ophthalmologists. As regards the primary hereditary hypermetropia, which is often the cause of the secondary strabismus, since the hypermetropic eye is smaller than normal, a deficiency of material may be the factor which produces it, or, and I think more probably, the defect may have a nervous origin. As regards the opposite condition of hereditary myopia, Mr. P. Smith writes § :—"Firstly, there is the hereditary predisposition. Different observers estimate the importance of this factor very differently, but hardly anyone will deny that under similar circumstances, the children of myopic parents are more liable than others to acquire myopia, and that this fact is a weighty one in relation to the general progress of the disorder through successive generations. Whether the transmitted tendency depends chiefly on peculiarities in the tissues of the eyes themselves, or on the mechanical relations subsisting between the eyes on the one hand, and

* *Cf.* Ribot, "Heredity," Engl. transl. p. 39.

† Traité compl. d'Ophthalm. vol. iii. p. 867.

‡ "Ueber angeb. vererb. Beweglichkeits-Defect der Augen," Klin. Monats. i. 1079.

§ Ophthal. Rev., June 1886.

the muscles, the optic nerves, and the orbits on the other, is not yet positively known. Secondly, there is the supposed correlation between the growth of the brain and the growth of the eye, by reason of which a high degree of cerebral development is apt to be associated with an overdevelopment of the eye." (The remaining two causes given in the paper quoted from are not germane to the subject of hereditary defects.) The consideration of the defects dealt with in this last section will be better deferred to the section in which the influence of nerve-action is discussed.

Absence of the External Ear.—Sedgwick * gives a case of absence of the left external ear—a father not himself presenting the defect, had a son who did; the father's cousin, a male, was affected as were two of his male children, a daughter escaping. This case, as he remarks, seems to point to the existence of the defect in some earlier ancestor. The same writer quotes a case recorded by Anderson Smith † in which a woman, two of her daughters, and two grand-daughters, had rudimentary lobules to their ears, the male children and grand-children being normal.

Cleft Lobule of the Ear.—This condition is of particular interest, since it was first brought into prominence by being advanced as an example of the heredity of a mutilation, in opposition to Weismann's views. So far from this being the case, the defect, now that attention has been directed to it, seems rather to support his contention. It is to be hoped that the stimulus to observation given by the publication of Weismann's Essays may lead to the clearing up of more of the many vexed questions in the field of Teratology. The history of the controversy on this condition is as follows. Dr. Emil Schmidt ‡ described a case in which the mother had acquired a cleft of the lobule of the left ear by the tearing through it of an earring whilst at play, at the age of 8 years. Of her eight children, the second, a boy, presented a cleft of the lobule of his left ear, which was regarded by Schmidt as an inheritance of the mother's mutilation. However, His § and Weismann ‖ have both pointed out that the cleft in the son's ear is quite different from that of the mother, and occupies a different position. Finally,

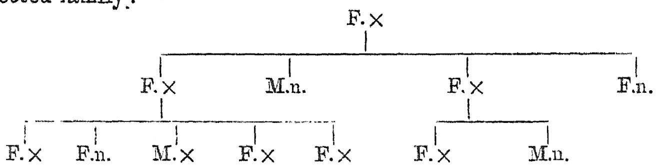
* Med.-Chir. Rev. vol. xxviii. p. 206. † *Ib.* vol. xxxi. p. 457.

‡ "Ueb. Vererbung individ. erworb. Eigensch.," Corresp.-Bl. d. deutschen Ges. f. Anthrop., Nov. 1888. § *Ib.* March 1889.

‖ 'Ueb. d. Hypothese einer Vererb. v. Verletzungen,' Jena, 1889.

Dr. Oscar Israel has published a paper * on the condition, in which he describes two similar cases in which there is no mutilation in the parents. Moveover, he points out that the cleft always has its site in the position of a fissure of normal occurrence in the development of the ear, which fissure has been called by His "Sulcus intertragicus." The malformation, therefore, falls into line with the other congenital clefts as an arrest of development.

Branchial Fistula.—A failure in the closing of the branchial clefts producing the condition known as branchial fistula is at times hereditary. In fact the influence of this factor appears to be considerable, since Heusinger † was able to trace its action in seventeen out of forty-six individuals. The following table given by Ahlfeld from Ascherson ‡ gives a good example of an affected family:—



The condition seems to be undoubtedly blastogenic, though whether due to lack of material or to nervous causes is not clear.

Hypospadias.—This malformation is sometimes hereditary. Lucas § gives a case in which grandfather and father both were affected; whilst the son had the same defect combined with atresia ani and rectum opening into the urethra. In another case, alluded to by both Darwin and Lucas, and originally described by Meckel ||, a female in whose family hypospadias was present, gave birth to two sons, both affected with the same deformity.

This exhausts the list, so far as I am aware, of hereditary malformations of the second sub-division. The last division, that of abnormalities not due to faults of formative material, which must next be dealt with, will not require any very lengthy consideration.

* "Angeb. Spalten d. Ohrläppchens," Virch. Arch. Bd. 119. S. 241. [Since this paper was written, several communications have appeared on the subject, the titles of which are here given for the sake of completeness:—Ornstein, Arch. f. Anthrop. t. xviii. f. 4; v. Swiecieki and His, Arch. f. Anat. u. Entw., Jahrg. 1890, Hft. 5 & 6; cf. also Laloy, "Malform. Héréd. du Pavillon de l'Oreille," L'Anthropologie, i. p. 5.—*Note*, Dec. 30, 1890.]

† Virch. Arch. Bd. 29. S. 358.

‡ De fistulis colli congenitis, Diss. pro venia legendi (Berlin, 1832).

§ (From Dr. Ritter von Rottembourg,) vol. i. p. 324.

|| Hdb. d. path. Anat. vol. i. p. 20.

Part 3.—*Malformations possibly Mechanical.*

It will be most convenient to take this group under the headings indicated in the first section.

Clefts due to Tumours.—Fœtuses born with such deformities are, I believe, almost always still-born. In any case I have never met with an account of any case where such a condition was hereditary.

Clefts due to Fluids of an Inflammatory Nature.—As examples of this may be mentioned such defects as abdominal fissure, sufferers from which are always still-born; anencephaly again, a condition in which life is impossible for more than a few hours at the most; with, possibly, spina bifida. Opinions are, however, divided on this question. "Which is the primary defect," says Mr. Treves *, "arrest of development in the bones, or dropsy of the membranes? Does the deficiency in the bony canal encourage a protrusion of the membranes? Or has the protrusion prevented the proper formation of the osseous canal?" To this question, he says, no satisfactory answer has yet been given.

Defects due to Formation of Inflammatory Fibrous Tissue.—That part of this section which relates to deficiencies of extremities has already been sufficiently dealt with in the paragraphs on Peromelia and Perodactyly, since most of what was there said in connection with the influence of amniotic bands in the production of defects might also be applied to the present question. As far as atresia ani is concerned, if any cases are attributable to the cause under consideration, that defect is of no importance so far as this inquiry is concerned, since there is no evidence, so far as I am aware, that it is ever hereditary.

Defects due to Amniotic Pressure.—These defects are of a totally different nature to those previously discussed in connection with the amnion. The defects of this class are due to the compressing action of an amnion free from obvious inflammation or other disease. This pressure may follow, it appears, from (1) a deficiency of liquor amnii, whereby the fœtus is brought too much under the influence of the amnion and possibly also of the uterine walls; (2) a want of sufficient growth on the part of the amnion itself, whereby the growing embryo is compressed; (3) possibly, the abnormal size of the

* Internat. Encycl. of Surgery, vol. iv. p. 891.

child itself. It is, however, unlikely that this factor, save perhaps in very rare cases, can produce any lasting effects. Every obstetrician has seen large children with their feet "tucked," to use the common phrase, but which have suffered no permanent injury. The malformation, however, which does require some consideration here is that of Talipes, which is at times hereditary, and which is thought by some to be caused by amniotic pressure. I shall, I think, give the best idea of opinion on this subject by some extracts from a very careful monograph on the question by Parker and Shattock *. With regard to nerve causes which have been considered by some to be the most probable solution, they say:—"By those who advocate this theory it is argued, that because talipes ensues after recognized nerve-lesions, a nerve-lesion must therefore be the cause of those forms of talipes which are congenital, since the two deformities are so outwardly alike. This argument, they think, is strengthened by the fact that talipes is often associated with malformations of the nerve-centres (such as anencephalism, spina bifida, &c.). In the first place, the supposed nerve-lesions have never been demonstrated. Apart from the fact that in our own case the nerve-centres and the nerve-trunks were perfectly normal, there are clinical facts which tell against the nerve theory of causation. The most important of these is that talipes is an accidental, and not an essential, sequel of paralysis .... If further evidence in this direction be needed it is to be found in the fact that congenital malformation of the nerve-centres occurs without the association of talipes, as is abundantly shown by the specimens of anencephalus preserved in museums; Mr. Pepper has recorded † a case of so-called complete absence of brain and cord associated with talipes calcaneus of both feet, among other deformities. In this case we should have to assume a negative action of the nerve-centres, a want of nerve-control, perhaps, if we would invoke a nerve-cause at all .... We think it quite possible in a few cases that there may be a nerve-lesion apart from such manifest conditions as spina bifida, &c. For very occasionally at the time of birth (and the same may be found at comparatively early ages in the fœtus) the limb is more or less atrophied, a condition which is especially observable when the

* Trans. Path. Soc. vol. xxxv. p. 423.

† Med. Press and Circ., May 8, 1878.

atrophy is confined to one side. We must, however, confess that we have no direct observations on the nerve-centres in support of these views. They are derived solely from clinical observations of cases, and the results may very well be put down as due to mechanical causes, and belong to the same category of cases as intra-uterine amputation &c." In conclusion, they say:—"We think that of all the explanations of club-foot hitherto offered, a mechanical one is the most reliable and satisfactory for the great majority of cases." Their remarks on heredity in connection with this malformation are also worth quoting. "With regard to heredity, the whole question is so obscure that it is hardly profitable. Although cases of hereditary transmission of the deformity from parents to children do undoubtedly occur, yet in the vast majority of instances no such hereditary influences can be traced, and this is even true in instances where several children in the same family have suffered. The influence of heredity, however, may be invoked with equal force, whatever view of the pathology of the disease be adopted. But at first sight it may seem not a little remarkable, that in some cases the deformity is transmitted along the paternal line; and it may be difficult to harmonise this fact with the influence of environment on which we have insisted. It need only be remarked, however, that the environment of the fœtus depends upon the fœtus itself, not less than upon the mother. For most recent observations show that the liquor amnii may be considered throughout a fœtal and not a maternal product. Excess or deficiency in its amount may, therefore, be the result of a tendency inherited either from the father or the mother." It is evident that no definite opinion can at present be hazarded as to the cause of talipes and, therefore, as to its nature, whether blastogenic or somatogenic.

Deficiencies due to Amniotic Adhesions.—These have already been discussed sufficiently in earlier sections.

Having now passed in review all the congenital malformations with which I am acquainted, it remains for me to consider in the succeeding sections certain general questions which appear to need a separate treatment. These include, *inter alia*, the effects of maternal impressions and of the maternal nutrition upon the development of the embryo; and the part, if any, played by the nervous system in the production of abnormalities during the same period.

Section III.—Consideration of certain possible causes of Malformations.

Part 1.—*Mental Impressions.*

Mental impressions of the pregnant woman reacting upon the developing fœtus were for years supposed to be a potent factor in the production of abnormalities. This question is an important one, since abnormalities so produced would be undoubtedly somatogenic. The theory has, however, been long abandoned by, I believe, all biologists. Vrolik * years ago formulated his reasons for denying its action. These reasons are to my mind unanswerable, and, in order that this paper may be as complete as possible, I shall reproduce them here with some additional comments.

(1) As Allen Thomson points out†, "It may be remarked that the stage of the period of pregnancy at which the injury of the child may take place is by no means defined, and that there is no correspondence between the time or advancement of the fœtus and the nature of the injury. Some injuries are said to have occurred or to have had their foundation laid at the very moment of conception, and even occasionally before that time, while others are inflicted only a few weeks before birth." Where by chance the time of the supposed "impression" does coincide with the malformation, and this is the case in a very small minority of instances, there is no reason to suppose that the occurrence is other than a coincidence, for the reasons which follow.

(2) "That malformations seldom, or perhaps never, agree with apprehensions or fears *à priori* of pregnant women (G. Vrolik, T. Zimmer, J. J. Plenck, and Burdach). On the contrary, it often happens that a woman who has once procreated a malformation, and is continually troubled by the fear of another similar sad occurrence, may become the happy mother of a second well-formed child." (*Vrolik.*)

(3) There is no nervous connection between mother and child through which such an impression could act. There is abundant evidence to show that a violent mental shock to the mother may cause the death of the fœtus and its subsequent expulsion. Thus Priestley ‡ says :—"There is no doubt greatly increased nervous

* Todd's Cyclop. of Anat. & Phys., Art. "Teratology."

† *Ib.* Art. "Generation." ‡ Pathology of Intra-Uterine Death, p. 68.

tension in all pregnant women. Fright, anxiety, a sudden impression made upon the mind or body, may not only initiate uterine contraction at any period of pregnancy, but there is every reason to believe that a sudden mental shock may at once kill the early embryo or more mature child even if it be retained some time afterwards. Repeatedly it has occurred to me, as to others in practice, to have patients dating the exact time of their child's death *in utero* to some alarm of shocking occurrence which has profoundly affected the whole nervous system. The immediate effect described was first violent perturbation and undue active movement of the child for a brief interval, followed by cessation of fœtal movement, and absolute quiescence in the future. In a few rare instances the woman has been mistaken in supposing her child to be dead after a shock or fright she has experienced, but in a large number of cases the relation between the cause and the effect has been too clear to be accounted for by mere coincidence, and the child has sooner or later been expelled dead, possibly both dead and putrid. It is no uncommon thing for a woman in early pregnancy, on the receipt of bad news, which much perturbs her, to be seized with uterine hæmorrhage, ending in abortion. Condemned women prior to execution have been known to abort beforehand, and, under the influence of terror and pain, martyred women in former days are said to have aborted at the stake. So potent is mental influence on the stability of pregnancy, that I have had reason to believe the mere dread of miscarriage has in some women been an important factor in bringing it about; and I have known pregnant women who have previously miscarried, get into such violent mental agitation as the time approached at which they had aborted before, that the event they feared was precipitated, and pregnancy was brought to a premature conclusion."

It is not difficult to understand how, by undue oxygenation of the blood leading to fœtal asphyxia, or by some chemical alteration in its constitution, at present unrecognized, the death of the embryo might be caused, but it does not appear how its mal-development can be accounted for by similar causes.

(4) Malformations, and those of a similar nature to those met with among human beings, occur amongst lower animals, where the effect of an "impression" can scarcely be postulated.

(5) One of a pair of twins may be malformed, whilst the other escapes.

(6) "More deeply situated organs, the very existence of which may be unknown to the pregnant woman, may be malformed; as, for instance, the heart, the intestinal tube, &c." (*Vrolik.*)

Finally, I may conclude this section with the words of Thomson:—"We conclude by adopting and expressing the words of Dr. Blundell, 'that it is contrary to reason, experience, and anatomy to believe that the strong attention of the mother's mind to a determinate object or event can cause a determinate or a specific impression upon the body of her child without any force or violence from without; and that it is equally improbable that, when the imagination is operating, the application of the mother's hand to any part of her own body will cause a disfiguration or specific impression on a corresponding part of the body of the child.'"

Part 2.—*Effect of Maternal Nutrition.*

The contention may possibly be raised, as has been hinted in earlier sections, that the state of the mother's nutrition during the period of pregnancy may be a factor in the production of abnormalities. The forms in which this kind of influence might *à priori* be expected most probably to take effect are those of dwarfs and giants, but as I endeavoured to show, when dealing with those groups, there is no evidence of this factor being of any importance; indeed there seems, on the contrary, good reason for the formation of an opposite opinion. The case of the lion-cubs affected with cleft-palate is, however, one which at first sight seems to lend some colour to such an hypothesis. In considering it, however, it must not be forgotten that these were not hereditary cases, but had, in all probability, a specific cause, and ceased to occur when that cause was removed. On the other hand, there are numbers of cases which might be cited where faults of excess and of defect co-existed in the same children, to explain both of which by the nutrition hypothesis would seem to be a very difficult matter. Thus, for example, in the Heinzler family polydactylism and defective development of the teeth co-existed. And, again, and this case is of special interest in connection with the lion-cub matter, Roux * has recorded an instance where a father and child were both the

* Lucas, *op. cit.* vol i. p. 307.

subjects of hare-lip and cleft-palate, and both also possessors of six digits. I may again revert to the views of Geddes and Thomson on the subject of the influence of nutrition on the determination of sex. Should it be the case that this is the determining factor, it would be a strong argument in favour of a direct somatic influence upon the germ-plasm, though even then it would not prove that the state of the maternal nutrition had anything to do with the production of abnormalities. Meantime the hypothesis just referred to requires a great deal more proof before its acceptance can become at all general.

Medical literature is full of cases illustrating the influence of the state of health of the parents, both male and female, in producing the early death of the fœtus, or the birth of sickly, ill-developed children. Dr. Priestley states that he knew of one case where a man the subject of slight albuminuria married a young woman apparently in perfect health. They had one child, delicate and fragile, within a year, and the wife aborted subsequently in three successive pregnancies—the husband growing weaker year by year, and eventually dying of uræmia. Lead-poisoning and other affections of the parents, most notably of all syphilis, may be followed by the same results. Again, as Stolz * has observed, fat women are often sterile and if they conceive are apt to abort. He believes this depends on nutrition taking an abnormal direction, and that the nutritive fluids destined for the nutrition of the embryo are thus insufficient for its development. All these influences, however, produce, as might be expected, general effects upon the whole fœtus, and not isolated or scattered abnormalities, at least so far as we at present know.

Part 3.—*Effect of Placental Diseases.*

Various diseases are known to attack the placenta, in many cases causing the death of the fœtus. Is it possible that these may in any instances lead to the production of abnormalities where insufficient to cause the death of the fœtus? I have searched through a considerable amount of medical literature without much result. Ercolani † does not mention any such possibility. In

* Des Accouchements (quoted by Priestley).

† Histology and Pathology of Reproduction.

fact the only note on the subject which I have been able to find is a remark by Priestley that Spath in nineteen cases in which calcareous concretions were present in the placenta, found one of congenital rachitis, one of spina bifida with hydrocephalus, and one of slight hydrocephalus. On which Priestley remarks that "the presence of calcareous deposits, in the placenta, therefore seems associated with some pathological conditions unfavourable to the welfare of the child, although the adverse influence does not proceed far enough in most cases to extinguish life." It is to be noted that the first and last of the cases mentioned are cases of fœtal disease, and that the second one, seeing that hydrocephalus was also present, almost certainly comes under the same category. As in the case of parental nutrition, it seems more likely that disease of the placenta would produce general rather than special effects upon the fœtus.

Section IV.—On the possible Nervous Origin of certain Malformations.

Part 1.—*Affections of a possibly Trophic Nature.*

Under this heading I desire to discuss the possibility of an inefficient action of the nerves during the development of the embryo being a cause of malformations. I have used the word "trophic," not because it quite expresses what I mean, but because I know of no better term. The point I wish to raise is, whether the trophic nerves or other nerves allied to them have not a potent action in directing the development of the embryo, and whether a failure for any reason on the part of these nerves to do their work may not be followed by certain malformations. In considering this question, it will first be advisable to learn what effects follow upon trophic failure in post-uterine life. Landois and Stirling * say in this connection, that the nutritive changes which follow in the eye, upon section of the ophthalmic division of the fifth nerve, are best explained by the theory of trophic fibres, whose centre is the Gasserian ganglion, and they proceed to state :—" The trophic disturbances which sometimes accompany affections of the trigeminus are particularly interesting. They

* Text-Book of Human Physiology, vol. ii. p. 796.

are—a brittle character of the hair, which frequently becomes grey or falls out; circumscribed areas of inflammation of the skin, and the appearance of a vesicular eruption upon the face (often following the distribution of certain nerves), which may also occur on the cornea, constituting the neuralgic herpes corneæ of Schmidt-Rimpler. Lastly, there is the progressive atrophy of the face, which is usually confined to one side, but may occur on both sides. It is caused very probably by atrophic affection of the trigeminus, although the vaso-motor nerves may also be affected reflexly." The following cases will illustrate the effects:—

(1) Otto Schmidt* was first affected at the age of ten, atrophy of the left side of the face commencing at that age. At the age of forty-one, the muscles, bones &c. of the left side of the face were much smaller than those of the right, and all the subcutaneous fat had quite disappeared, no hair save a very small moustache growing upon that side. The left orbit was much larger and the eye deeply sunken from disappearance of the post-orbital fat. Atrophy did not extend beyond the vertex. The median line of the face was crescentic, with the concavity directed to the left, from the shrinking of that side. The left side of the tongue was atrophied, and the sight of the left eye impaired, though not from atrophy of the optic nerve. The sense of smell and discharge of mucus were both less on the left side than on the right. All these changes were probably due to some lesion of the trophic fibres of the trigeminus.

(2) Dr. Stewart† has recorded a case where the patient, a boy, aged 14, was severely frost-bitten at the age of ten, on the left cheek and ear. Eighteen months after, atrophy was first noticed. Two years later, when he came under notice, atrophy affected those parts of the face innervated by the two lower divisions of the fifth nerve. The skin, subcutaneous tissue, muscles, and bones were all atrophied, the muscles least. The lower jaw was thinner and shorter, and the upper distinctly atrophied on the left side. The teeth were well developed. Owing to atrophy of the turbinated bones, the left nostril was wider than the right. There was distinct atrophy of the left half

* The account is taken from a note made when Prof. Purser showed the patient to his class in the University of Dublin.

† Montreal Med. Journ.

of the tongue, more marked anteriorly. There was no affection of any of the special senses, nor any disturbance of deep or superficial sensation, nor was there any difference of temperature between the two sides.

(3) Mendel* has reported the results of a very thorough examination he made of the fifth nerve in a case of facial hemiatrophy, of many years' standing, in a woman. This woman had also atrophy in the region innervated by the left musculo-spiral nerve. She died from phthisis. Her case was first described by Romberg and more recently by Virchow. The symptoms were those of a typical left facial hemiatrophy. Mendel found all the branches of the left fifth nerve, from their origin to their termination, the seat of a proliferating neuritis. A marked and similar difference was found in the size of the right and left descending roots of the fifth nerve, and also in the substantia ferruginea, the alleged nucleus of the so-called trophic root of the fifth nerve. This examination shows that, at least in some cases of facial hemiatrophy, we have to do with a neuritis of the fifth nerve.

Such being the effects of trophic lesions in post-uterine life, we have now to consider what evidence there is for any similar affections occurring in the developing fœtus. We know, unfortunately, so very little about the directing causes of development in the embryo, that all speculation of this nature must be somewhat hazardous. I shall now detail such cases as I have met with, as seem to lend probability to such an action of the nerves during development as I am arguing for.

(1) I have first to revert to the exceedingly interesting remarks made by Oakley Coles, in his chapter on the etiology of cleft-palate, to which I have already referred, but which must now be more particularly considered. "The frequent association," he says, "of cleft-palate with defective development of the brain has long been observed †, and various hypotheses have been put forward to explain the connection. Thus, in the early part of the century, Tiedemann ‡ observed that in certain cases of cleft-palate the nerves of smell are wanting or imperfectly formed, and

* Neurol. Centralbl., July 15, 1888.

† Leuckart, 'Untersuch. üb. den Zwischen Kiefer-Knochen des Menschen,' Stuttgart, 1840.

‡ Zeitschr. f. Phys. Bd. i. S. 71.

he was therefore inclined to attribute the deformity in the palate to a deficient development of the framework of the olfactory organ consequent upon the nervous defect. This view, however, never met with any general acceptance, and M. J. Weber (no mean authority on the subject) states * that he has never seen the olfactory nerves absent in any case of fissured palate. According to Dr. Engel, on the other hand, the deformity is due to increased breadth of the anterior portion of the head, caused by a variety of conditions of embryonic life, such as hernia cerebri, dropsy of the third ventricle or of the lateral cornua of the lateral ventricles, or excessive development of the anterior cerebral lobes. Or, in other words, to a purely mechanical disturbance of the relative position of the parts involved. But while admitting the accuracy of Dr. Engel's observations, it is impossible to accept his deductions from them. For cleft-palate is found to occur more frequently in connection with a microcephalic skull than under the conditions quoted by Dr. Engel; and thus his hypothesis, even if true, would only explain the causation of a limited proportion of cases. It is far more probable, however, that the relations between the two deformities, the cerebral and the palatal, is not one of causation, but one of concurrence, both being common effects of a grave vice in the developmental energy of the fœtus. . . . All, perhaps, that we can safely say on the subject at present is that cleft-palate, hare-lip, and other similar anomalies of development do frequently occur in conjunction with faulty development of the brain, whether bilateral or unilateral, hypertrophic or atrophic; and it is quite possible that the two kinds of deformity may be related to each other as cause and effect. But the facts that hemicephalic and microcephalic infants are born with perfect palates, while the subjects of palatal deformity are in many cases of high intellectual power, would appear to show that the two deformities are rather the combined effects of a common cause." Again, after speaking of the perfect condition of the palates of ancient and modern uncivilized races, and comparing their state with that of civilized races, he says:—" We shall be led to the inevitable conclusion that the relation between a high state of civilization and a high proportion of palatal deformity is something more than a mere matter of coincidence; and the strength of such conclusion will not be lessened by the state-

* Froriep's Notizen, Bd. xix. No. 18, S. 282.

ments of Walther* and Langenbeck †, both of whom maintain that the severer forms of cleft-palate have become more common within their own recollection. To draw more precise conclusions from considerations such as the above," he proceeds, "would be beyond the scope of the present article, but it may not perhaps be out of place to suggest that the difference between the conditions of civilized and uncivilized life is quite as much a matter of increased nervous strain as of changed physical environment; that the over-taxed nervous system, which in the parent manifested itself only by functional instability and subjective remonstrance, may, in the child, issue in objective defect and an actual refusal to complete its alloted task."

(2) Dr. Langdon Down has drawn attention to the occurrence of palatine abnormalities in congenital idiots. Out of two hundred cases observed eighty-two "possessed palates inordinately arched, and with this increased arching were noticed various abnormalities. In seven the palate-bones did not meet, leaving a sulcus between them, the mucous membrane being, however, continuous. There was no instance of the ordinary cleft-palate, and I may remark that in an examination of nearly six hundred idiots, I have failed in meeting with an example of that deformity. In several the hard palate extended but a short distance posteriorly from defect of the palatal process of the superior maxillary bone and entire absence of the palatal bone, and in all these cases the velum palati was unusually flaccid. In the majority of cases there was marked narrowness of the palate" ‡.

(3) In describing cases of hereditary ataxia, or Friedreich's disease, my colleague Dr. Suckling says that the association of the disease with other deformities is interesting. "In the one family, one son was born with deformity of the foot, and a daughter with only one upper limb. In the other family two cousins were born bald. There is no doubt that the deficiency in the nervous tracts is a congenital one, and due to a fault in development" §.

(4) Beigel ‖, in a paper on albinism and nigrism, gives it as his opinion that these conditions are due to nervous affections.

* Graefe u. Walther's Journal, Bd. xxi. S. 175.

† Neue Bibliothek für die Chirurgie, Bd. iv. Hft. 3, S. 492.

‡ Mental Affections of Childhood and Youth, p. 159.

§ Repr. from Illustrated Med. News, 1890.

‖ Virch. Arch. xliii. 529.

(5) Stricker * gives the case of a family where, amongst hair otherwise perfectly black, a white lock existed. This abnormality ran five generations, the first individual known to possess it having lived in 1720, and the case having been described in 1877. If Beigel's view be correct, this may also have been due to a nervous defect. It is, indeed, difficult to know how else to account for it.

(6) Mr. Lloyd Owen † has described carefully a case where congenital nystagmus was transmitted through four generations. This condition appears to be due to some congenital defect of the nerve-centres.

(7) Bland Sutton ‡ gives the following case.—" A woman in the fifth month of gestation fell downstairs on her abdomen. At the eighth month she was delivered of a child, the upper part of the body presenting the proportions of a fœtus of corresponding date, but all parts below the navel agreed with those of an embryo of the fifth month of intra-uterine life. Dissection showed that the spinal column ended at the first lumbar vertebra, the remaining lumbar, sacral, and coccygeal elements being absent. The skin of the legs was exceedingly thin, and, on reflecting it, the bones were found to be thin and to present the characters of those of an embryo of the fifth month. All the other tissues of the legs, muscles, nerves, ligaments, &c., were represented by adipose tissue. In this instance it is probable that when the mother fell, she fractured the spine of the fœtus ; the result was to cut off nervous influences from the legs, which in consequence retrograded into fat." He refers to other examples of this fatty degeneration subsequent to loss of nerve-influence §, and says that " there seems to be, as Otto ‖ was the first to demonstrate, some intimate relation between absence of nerves and fatty degeneration ; and he points out that parasitic fœtuses, which, as a rule, are devoid of nerves, always contain a very large quantity of fat in lieu of more important tissue-muscles and the like."

(8) Furst ¶ narrates a case where chronic hydrocephalus was accompanied by cessation of growth.

* " Noch eine Familie von Haarmenschen," Virch. Arch. lxxiii. 622.

† Ophthal. Rev. vol. i. p. 239.

‡ Introduction to General Pathology,' p. 85.

§ Med.-Chir. Soc. Trans. lxviii. p. 293.

‖ Compendium of Human and Comp. Path. Anat. (South's transl., 1831).

¶ Virch. Arch. xcvi. 357.

(9) Gowers * has described the condition of the brain in a case of congenital absence of one hand. The subject was a male, aged 40, who was born without a left hand. The forearm bones were well developed, but at the extremity there was only an irregular mass of bone consisting apparently of the two rows of carpal bones, very imperfectly developed and anchylosed together except at one point. In the brain there was a marked difference between the two ascending parietal convolutions. At their origin at the longitudinal fissure, for the first inch of their extent, they were nearly equal in size, and continued nearly equal for the upper $1\frac{1}{2}$ inches. In the next (middle) two inches there was a very marked difference, the right being a narrow single convolution, and the left broad and depressed by a slight secondary sulcus. This occupies precisely the area, stimulation of which, according to the experiments of Ferrier upon monkeys, causes movements of the opposite hand. It is, of course, impossible to say whether the brain or the hand defect was the primary one. The following remark of the author, however, renders it possible that the former may have been the cause:—"I am not aware that the brain has been examined in any similar case. In several instances, in cases of old amputations of the arm, an atrophy has been found, but it has been slight, and has not been uniformly localised."

These facts, I think, render it probable that the nervous system exercises more influence upon the course of development than has been hitherto attributed to it. It is true that, on the opposite side, it may be urged that anencephalous fœtuses are fairly well developed and are yet without brain. To this it may be replied—1st, that the development is more apparent than real, since the bodies of such fœtuses are always overloaded with fat, a condition which, as we have seen, follows upon loss of nerve influence; and 2nd, that we do not know the date at which the disease occurs which causes the defect. Certainly it is later than the period at which the eyes are fully formed. It may be that the disease does not occur until after development has proceeded sufficiently far to proceed with the remnants of nerve system which exist. It must not be forgotten that these forms sometimes live and breathe for a short time, showing the existence of some important parts of the nervous system.

As regards the kinds of malformations most likely to follow

* 'Brain,' Oct. 1878.

upon a loss of nervous influence, it appears to me that many of the clefts can best be accounted for in this way. For example, it is a little difficult to see how a branchial fistula can depend upon a lack of material, since the aperture at the time of failure to close must be excessively small. On the other hand, it is not difficult to see how a failure of power to close, due to a want of nerve influence, may cause the persistence of the cleft. A similar explanation may be offered for some of the forms of cleft-palate where there is no apparent lack of material. The co-existence of several malformations in the same region seems to point to some common cause, which is most probably to be sought for in the nervous system. Such grouped malformations occur most often in the face in connection with ears, eyes, and palate. It is suggestive to observe that these are in the region of supply of the trigeminus nerve, and that, as Anstie * observes, "the nervous centre in which the trigeminus is implanted is, of all nervous centres, the one which in the human subject is most liable to congenital imperfection of the kind which necessitates a break-down in its governing functions at special crises in the development of the organism."

Here at present I must leave the subject of the connection of nerve influence and congenital lesions; at a later part of this paper I shall recur to it in relation to the origin and development of a malformation.

Part 2.—*Affections due to Excessive and Irregular Nerve-impulse and Muscular Contractions.*

It is, of course, a well-known fact that the child after a certain period of intra-uterine existence is capable of making a considerable amount of use of its muscles, and, moreover, that the amount of movement varies in different children. Many have held that an excess of this movement, exercised with irregularity, is the cause of various malformations. Talipes is that which has been most commonly attributed to its influence; thus Lowne † groups the various forms of that defect under the heading of "Distortion from irregular muscular contraction." These malformations, he says, "are probably due to some form of cerebro-spinal irritation or defect." Again, speaking especially of the various forms

* Lancet, 1866, i. p. 654.

† Teratological Catalogue of Roy. Coll. of Surgeons of England.

of talipes, he says, "The question of their origin from irregular muscular contraction is still an open one; but the arguments in favour of this view are exceedingly strong." Messrs. Parker and Shattock, as has before been mentioned, take a different view as to the etiology of the condition. In their specimen it is true that a microscopical examination revealed no lesion in the central nervous system; at the same time it is a matter for argument whether this is proof positive that no nervous influence was concerned in the production of the condition. It seems to me at least possible that some temporary stimulus, say of a chemical nature, might set up irregular contractions in the muscles, without any changes resulting in the nervous system. We know that drugs administered to the mother can affect the fœtus, and the same may be true of other chemical stimuli of which we may know little or nothing. If this be true, the resulting lesions would be somatogenic in their nature; but we are at present in ignorance as to whether, in the first place, all lesions which are attributed to this cause are really due to it, or whether some of them may not follow upon a lack of material, as seems probable, in which case they would be blastogenic in their nature. And, secondly, supposing that these lesions owe their origin to more than one cause, we have no method, at present, of distinguishing between the two or more classes. Here, as in many other instances, it is much to be hoped that teratological workers will direct, in the future, more attention to the causation of malformations, so that these and other cognate problems may be cleared up.

Section V.—Hereditary Disease.

The subject of hereditary disease is one which should not be neglected in an inquiry of this kind. I purpose, therefore, devoting a few lines to this subject in its connection with the present topic.

The greatest confusion has been introduced into the controversy on acquired characters by some who have mixed up the various kinds of hereditary diseases, which fall into classes of the most divergent nature, with one another and with hereditary variations and malformations. It will, then, be advisable to state what are the groups of hereditary diseases considered in relation to the present inquiry.

(1) There are diseases due to a specific infection, probably always bacterial in its nature. Small-pox and other similar diseases, with which the fœtus may be infected by the mother, are of this kind. The commonest and best example is, however, that of syphilis, which may be communicated to the embryo by its mother, or to the embryo by the father, and by the embryo, in turn, to its previously uninfected mother. Diseases of this kind have no bearing whatsoever upon the present question, though it is sometimes imagined that they have.

(2) There are conditions of the embryo induced by the presence of a poison, not bacterial in its nature, which may be present in the parental organism at the time of impregnation. To this group may possibly be assigned the cases of early intra-uterine death or congenital feebleness of the embryo, which, as has been already stated, are caused by lead-poisoning in the male parent. Those cases, also, where feebleness of mind or body in the child seems to be the result of chronic alcoholism in the parent or parents. In connection with this subject I cannot refrain from mentioning the remarkable statements of Dr. Langdon Down * as to the effects of intoxication in the parents on the offspring. The case which he gives is that of a child (female) aged five years, without any deformity, but only 22 inches in height, and unable to speak. The first child of the family was healthy. Prior to the procreation of the second the father took to drink, the offspring dying at the age of three years, and during its life resembling that described above. The third was the child first mentioned; and the father was drunk when he procreated it. The fourth was a miscarriage. At this period the father became again a sober man, and his wife had subsequently five perfectly normal children. The above case, the author says, is of great interest, because it adds another to a group of cases which have come under his observation, of arrested development arising from the intoxication of one or both of the progenitors at the time of the procreative act. The whole group of cases has presented features of such close resemblance that it is difficult to avoid the conclusion that there was some unity of cause, and careful investigation has elicited facts bearing on the etiology of these cases having a close parallelism to the circumstances which he believes to have been potential in this. He has known some of these

* Trans. Path. Soc. xx. 419.

cases to attain the age of twenty, while still preserving infantile characteristics. If these deductions be true, it certainly would seem as if the soma was capable of exercising a greater influence upon the germ-plasm and its development than some writers are prepared to admit.

(3) There are the diseases commonly called hereditary, such as gout, rheumatism, phthisis, and hæmophilia. These require a little consideration. The first two are due to some fault in the chemical processes in the body, and at first sight seem to have little to do with the subject of congenital malformations. I believe, however, that this is more apparent than real, and that, as a matter of fact, they are more closely allied than on the surface appears to be the case. It is true that it is the chemical process which is at fault, but the primary flaw must surely be in the laboratory in which they take place. To say that we do not know the physical explanation of the failure, is no more than to say that we have not yet penetrated all the mysteries of human pathology. In the hereditary cases it would seem that the parent transmits to the offspring a flaw or weakness in the chemical apparatus, which under strain leads to its subsequent breakdown and the appearance of the characteristic disease. Such a flaw or weakness may surely with correctness be called an hereditary malformation. Again, as regards phthisis, the tubercular bacillus is only one factor in the disease: there must also be a suitable nidus or soil for it to take root in; the condition of tissue, whether intestinal, pulmonary, or otherwise, which provides this suitable soil is often hereditary, and may fairly be looked upon as an hereditary malformation. As regards hæmophilia, there can be little difficulty in seeing that the hereditary malformation consists in some faulty construction in the walls of the blood-vessels, which prevents them from behaving in the normal manner when cut or torn. As regards cancer and its heredity, since we are quite ignorant as to the cause of that complaint, it is useless trying to form any theory to account for its transmission. In the next and concluding section, I shall have to discuss the bearing of these facts upon the question involved in this paper.

Section VI.—Conclusion.

I have at various points in this paper had to allude to the unfortunate gaps in our teratological knowledge, which make the drawing of indisputable conclusions so very hazardous. I shall therefore content myself with briefly indicating those points which have chiefly struck me in working at the subject. Even if the deductions be inaccurate, the facts and words of others collected in this paper may render it of some service to others working at the same subject, and probably especially so to those who are not members of the medical profession, and who are therefore perhaps less conversant with its literature than those who, like myself, are in the constant habit of referring to it. I will now mention the points to which I have above alluded.

(1) It is an interesting point that those malformations whose blastogenic nature is least in doubt are, speaking generally, those also whose hereditary nature is most distinct. I would refer, as an example, to polydactyly.

(2) Again, it is interesting that those malformations which are undoubtedly somatogenic are, so far as I know, non-hereditary. I allude to the abnormalities described in Section II. Part 3, but the remark just made must be taken with the limitation that so many of these forms are still-born or survive but a brief period. It might be thought that a further limitation should be made on account of the difficulty that gravely deformed persons might find in getting married; but this is, I think, an unnecessary limitation. The study of teratological literature almost seems to teach one that any person of either sex can get married if they desire it. Let me give an example from both sexes. Butcher * has figured a woman and her child both affected with the most aggravated form of double hare-lip and cleft-palate, than which scarcely anything can lend a more horrible appearance to the face. Butcher operated upon both at the same time and remedied the defects to a large extent. On the other side, I knew of a man quite destitute of both upper and lower extremities, who was not only married but the progenitor of a well-formed and handsome progeny. I do not know the cause of the defect in his case.

(3) It must be admitted that besides the cases which have been alluded to in the above two sections, there remain still a number of others as to which no definite conclusion can be, at present,

* Dubl. Journ. of Med. Sci. lxiii. 426.

arrived at. These have been already sufficiently indicated in the earlier sections of this paper, and need not, therefore, be now further specified. Much more extended observations will be required in most of these cases before it will be possible to settle the question as to their nature.

(4) There are certain malformations which suggest the possibility that they may have been gradually acquired and subsequently transmitted to descendants. Some of these may now be briefly mentioned. The question of hereditary myopia and hypermetropia is one which Weismann has considered in his essay "On Heredity"*. He there states :—"Those fluctuations on either side of the average which we call hypermetropia and myopia, occur in the same manner, and are due to the same causes, as those which operate in producing degeneration in the eyes of cave-dwelling animals. If, therefore, we not unfrequently meet with families in which myopia is hereditary, such results may be attributed to the transmission of an accidental disposition on the part of the germ, instead of to the transmission of acquired short-sightedness. A very large proportion of short-sighted people do not owe their affliction to inheritance at all, but have acquired it for themselves; for there is no doubt that a normal eye may be rendered myopic in the course of a lifetime by continually looking at objects from a very short distance, even when no hereditary predisposition towards the disease can be shown to exist. Such a change would of course appear more readily if there was also a corresponding predisposition on the part of the eye. But I should not explain this widely-spread predisposition towards myopia as due to the transmission of acquired short-sightedness, but to the greater variability of the eye, which necessarily results from the cessation of the controlling influence of natural selection." I have already mentioned that Mr. Priestley Smith has stated that there is a supposed correlation between the growth of the brain and the growth of the eye, by reason of which a high degree of cerebral development is apt to be associated with an over-development of the eye. If this be so, apparently the brain condition is the primary factor, at least in a certain number of cases. But the brain condition may be due to variations in the germ itself and, therefore, blastogenic in nature, and the inheritance of the defect might follow without any necessity for an appeal to the heredity

* English ed. (Poulton), p. 89.

of an acquired defect to account for it. But it is a question whether an explanation such as this can be held to account for all the cases of hereditary myopia. In his essay, however, "On the Supposed Botanical Proofs of the Transmission of Acquired Characters" *, the author seems to admit a modification of his views as first expressed, which are of great importance in connection with the question of the inheritance of the group of defects at present under consideration. Dr. Mivart in reviewing these essays † makes the following comment on this modification:—"Although these last two essays are intended to show that acquired characters cannot be inherited, they yet seem to us to show that to a certain extent, and in a certain sense, they may be inherited. We have no desire to contend that they are heritable to any large extent, and we have always affirmed that mutilations can at the most be very rarely inherited, and long ago referred to obvious proofs that so it must be ‡. But Professor Weismann here certainly makes some admissions with respect to the cumulative effect of a changed environment on the germ-plasm of organisms, which contradict his previous assertions that only unicellular creatures can be thus modified. But if such a cumulative effect does exist, then, if sufficient time be allowed (and Darwinians are prodigal of time), a modified Lamarckism reappears!" It is possible that in the direction thus indicated an explanation may yet be found for some of these conditions. But the whole subject, so far as the eye-defects are concerned, wants working out thoroughly by practical ophthalmologists.

(5) There are certain points which should be noted, since they seem to indicate the gradual rise and development of a malformation. I will mention two examples. The first is that of the precursory conditions, so to speak, of cleft-palate and hare-lip which were mentioned when that subject was under consideration; these are of great interest. Again, in connection with the same subject, it should be mentioned that Lucas § has published observations which lead him to conclude that an absence of incisors in a parent is premonitory of cleft-palate or hare-lip in the children, and he has given several cases in support of this theory. I am bound to say that my colleague Mr. Humphreys and myself, when working

* *Ib.* p. 413. † Dub. Review, 1889, p. 269.
‡ Genesis of Species, 2nd ed. p. 242.
§ Brit. Med. Journ., Dec. 3, 1887, p. 1212.

at the subjects of increase and diminution of the incisors *, did not meet with any cases which bore out this theory; but this, of course, does not prove that in certain cases it may not be true. If so, it strengthens the argument in favour of precursory conditions for some cases of palatal and labial defect. The second example is quoted by Page † from Boehm ‡. A woman had "beautiful blue eyes, delicate white skin, and, what is especially characteristic of a tendency to albinism, colourless eyebrows and eyelashes." Her daughter had white eyebrows, lashes, and skin, and great irritability to light, whilst the grand-daughter had internal strabismus and nystagmus, and hair "originally as white as well-bleached linen." Some other cases of a cumulative nature are given in my previous paper. It seems to me possible that these cases are due to an original flaw in the nervous system. Whether this flaw is due to a failure of development consequent upon conditions inherent in the germ, or upon the slow effect of some condition connected with the environment acting upon several generations, as was suggested by Coles when writing about cleft-palate, and as Weismann seems to hint may be the case in the essay referred to above, must at present and for a long time remain an open question. But in either case the nervous defect would precede the more obvious one, and may in an earlier generation exhibit its effects in a manner perhaps never recognized, by slight trophic disturbances and the like. Descending further and gathering force as it descends, under favourable circumstances, the conditions met with, at times, in the parents of children with cleft-palate or whatever the defect may be will be reached, and in the next generation or in one closely succeeding the full defect may appear, the precursory conditions having been quite unnoticed. I do not wish it to be understood that I am arguing either that all malformations have a nervous origin or that the chain of events which I have suggested, or one of a similar nature, occurs in all cases; what I desire to point out is that in some cases, and perhaps in more than at present we have any idea of, such precursory conditions may be capable, by diligent inquiry, of demonstration. In these facts we also may, I think, find a clue to the real significance of the much-abused word "tendency."

This word, and especially in its relation to the so-called here-

* Journ. of Anat. and Phys. vol. xxi. p. 84. † 'Lancet,' Aug. 8, 1874.

‡ Der Nystagmus und dessen Heilung.

ditary diseases, means that there is at present in the subject a minor condition of the nature of a congenital malformation. It is possible that under the most favourable conditions of life for the given defect it may never lead to a breakdown or become apparent, whilst under other and less favourable circumstances the weak point may give way and the defect become obvious. Such an explanation as this might be without hesitation accepted as accounting for the varieties of eye-defects recently referred to; and I believe that further investigation will show, as far as demonstration is possible, that the same line of argument may be used, not only with regard to the remaining diseases of the hereditary group described as (3) in Section V., but also to some at least of the congenital and hereditary malformations as well.

A Revision of the *Forficulidæ*, with Descriptions of New Species in the British Museum. By W. F. Kirby, F.L.S., F.E.S., of the British Museum (Natural History).

[Read 19th June, 1890.]

(Plate XII.)

The Forficulidæ, or Earwigs, have hitherto attracted less attention from Entomologists than any other group of Orthoptera. There are but few papers of any importance on the group; those by Dohrn in the 'Stettiner entomologische Zeitung' (vols. 24–26, 1863–1865), which include a descriptive synopsis, and Scudder's Catalogue of all the described species, in vol. 18 of the 'Proceedings of the Boston Society of Natural History' (1877), being the most useful. Since then several species have been described by De Bormans, Karsch, and others in various foreign periodicals.

Having lately rearranged this group in the British Museum, I judged that it would give a useful impetus to its study to publish a revised synopsis of the genera on the lines already indicated by Dohrn and De Bormans, and to describe as many new species as were before me in sufficiently good condition. Several of these were ticketed with MS. names by Prof. Westwood, which I have usually adopted.

One great drawback in the study of the Forficulidæ is deficiency of material. They are usually received in very small numbers and rarely in quite perfect condition, the antennæ, which are

extremely important for their classification, being almost always more or less broken. In many cases the sexes differ considerably, especially in the shape of the forceps. This usually varies considerably in the sexes, as well as in different individuals of the same sex, and yet there seems reason to believe that it will ultimately prove to be an important generic character. But for this purpose much larger series of specimens of both sexes and in different stages of development are required; and therefore I have refrained for the present from creating a multiplicity of new genera, though the mass of species included by Dohrn in *Forficula* is greatly in need of subdivision.

I consider the best method of measuring these insects to be from the point of the head to the end of the forceps, and also from the base of the last dorsal segment to the end of the forceps.

The number of species at present known is 348, including 39 described as new in the present paper, but exclusive of one or two doubtful larval (?) forms, perhaps not strictly belonging to the Forficulidæ (*Condylopalama*, Sund., and *Typhlolabia*, Scudd., the latter of which probably = *Iapyx* (*Thysanura*).

The genus *Pyragra*, Serv., which is imperfectly known at present, is likewise excluded from the Table. It is a South-American genus, probably allied to *Labidura*, and may be distinguished from *Demogorgon* by the presence of well-developed wings. (A few species, *doubtfully* referred to various genera in the following pages, may not always fully conform to the characters given in the Table.)

Genus I. Apachyus, *Serv.*

Serv. Ann. Sci. Nat. xxii. p. 35 (1831).

Apachya, *Serv. Orth.* p. 54 (1839); *Dohrn, Stett. ent. Zeit.* xxiv. p. 42 (1863).

Type, *Forficula depressa*, Beauv., from W. Africa.

Not represented in the Museum Collection.

Genus II. Tagalina, *Dohrn.*

Dohrn, Stett. ent. Zeit. xxiv. p. 44 (1863).

Type, *T. grandiventris*, Blanch., from the Solomon Islands.

There is one immature and imperfect specimen from Dinner Island, in the Museum Collection; probably a new species, but it would be useless to describe it.

TABLE OF THE GENERA OF THE FORFICULIDÆ.

(1)	Scutellum conspicuous; tegmina and wings always developed. (2)		
	Scutellum not conspicuous, except in some subapterous species. (9)		
(2)	First joint of the tarsi not longer than the second. (3)		
	First joint of the tarsi much longer than the second. (4).		
(3)	First joint of the tarsi simple; body depressed	**Apachyus.**	Africa, Madagascar, Papua
	First joint of the tarsi broad; body convex	**Tagalina.**	Eastern Islands.
(4)	Antennæ with less than 12 joints	**Neolobophora.**	America.
	Antennæ with more than 12 joints. (5)		
(5)	Large species, with upwards of 25 joints to the antennæ. (6)		
	Small species, with less than 25 joints to the antennæ. (7)		
(6)	Tegmina regularly rounded behind	**Pygidicrana.**	General Distribution.
	Tegmina obliquely truncated behind	**Thermastris.**	America.
(7)	Antennæ with the joints beyond the 4th much longer than the 3rd and 4th, and cylindrical. (8)		
	Antennæ with the joints beyond the 4th gradually lengthening, pyriform	**Nannopygia.**	Ceylon.
(8)	Abdomen with segments 2 and 3 not laterally tuberculate	**Cylindrogaster.**	America, Java.
	Abdomen with segments 2 and 3 laterally tuberculate	**Diplatys.**	Africa.
(9)	Second joint of the tarsi simple. (10)		
	Second joint of the tarsi dilated or lobate. (23)		
(10)	Abdomen with segments 2 and 3 not laterally tuberculate (spiny in some Indian species not yet separated from *Labidura*). (11)		
	Abdomen with segments 2 and 3 laterally tuberculate. (17)		
(11)	Tegmina always, wings usually, well developed. (12)		
	Tegmina and wings undeveloped	**Brachylabis.**	S. America, Java.
(12)	Body much depressed	**Platylabia.**	Eastern Islands.
	Body not remarkably depressed. (13)		
(13)	Body pubescent, short, broad; forceps semicircular in male	**Echinosoma.**	Africa, E. Indies, Australia.
	Body less pubescent, long; forceps not semicircular in male. (14)		
(14)	Forceps thickened and nearly contiguous at base. (15)		
	Forceps less thickened at base and widely apart in male. (16)		

(15)	Forceps with large teeth on the thickened basal part	**Labidurodes.**	Papua.
	Forceps regularly denticulated or unarmed	**Psalis.**	America; W. Africa (?).
(16)	Abdomen strongly punctured; hinder edges of the segments not milled in the typical species	**Labidura.**	Old World.
	Abdomen less strongly punctured; hinder edges of the segments milled	**Demogorgon.**	S. America.
(17)	Body much depressed. (18)		
	Body not remarkably depressed. (20)		
(18)	Antennæ 11-jointed	**Chætospania.**	Madagascar.
	Antennæ 15- to 20-jointed. (19)		
(19)	Antennæ with joints 3–6 equal, cylindrical	**Sparatta.**	Sumatra, Australia, S. America.
	Antennæ with joints 4–6 ovoid, very short; 3 much longer	**Mecomera.**	S. America.
(20)	Tegmina absent or rudimentary; wings absent	**Anisolabis.**	General Distribution.
	Tegmina always, wings usually, present. (21)		
(21)	Forceps very long and slender. (22)		
	Forceps not remarkably long and slender	**Labia.**	General Distribution.
(22)	Legs short	**Auchenomus.**	Madagascar.
	Legs long	**Spongophora.**	General Distribution.
(23)	Second joint of tarsi produced into a lobe under the third	**Chelisoches.**	Old World.
	Second joint of tarsi short, dilated. (24)		
(24)	Forceps contiguous at base in male. (25)		
	Forceps diverging at base in male. (26)		
(25)	Forceps flattened at base in male, then diverging	**Forficula.**	General Distribution.
	Forceps subcontiguous throughout	**Carcinophora.**	S. America.
(26)	Wings and tegmina absent or rudimentary. (27)		
	Wings and tegmina usually well-developed. (28)		
(27)	Small species; abdomen broadest in the middle	**Apterygida.**	
	Large species; abdomen broadest at the extremity	**Chelidura.**	
(28)	Abdomen slender, sides nearly parallel	**Sphingolabis.**	
	Abdomen short, often stout and dilated. (29)		
(29)	Legs very long and slender. (30)		
	Legs not remarkably long and slender	**Anechura.**	
(30)	Abdomen with long lateral recurved spines in male; forceps usually stout	**Ancistrogaster.**	S. America.
	Abdomen unarmed, or with short lateral spines, not recurved in male	**Opisthocosmia.**	

Genus III. PYGIDICRANA, *Serv.*

Serv. Ann. Sci. Nat. xxii. p. 30 (1831); *Orth.* p. 19 (1839); *Dohrn, Stett. ent. Zeit.* xxiv. p. 46 (1863).

Type, *P. v.-nigrum*, Serv., from Brazil.

PYGIDICRANA HORSFIELDI, sp. n. (Pl. XII. figs. 11, 11 *a*.)

Long. corp. 21 millim.; segm. term. cum forcip. 6 millim.

Male. Blackish-brown; antennæ upwards of 22-jointed; clypeus, except at base, lower mouth-parts, and legs rufo-testaceous; lateral borders of pronotum and wings straw-coloured; tegmina and forceps inclining to chestnut; terminal segment of abdomen very large, fully as large as the four penultimate segments together; forceps about as long as the terminal segment, simple, pointed, and strongly upcurved at the extremity.

Hab. Java (*Horsfield*).

Allied to *P. pallidipennis*, De Haan, but much smaller and darker.

PYGIDICRANA STAPHYLINOIDES, *Walk.*

Olyntha staphylinoides, *Walk. List Neur. Ins. B. M.* iii. p. 532, n. 3 (1853).

Described by Walker from a headless and tailless fragment; but a second specimen, likewise in poor condition and immature, shows it to be a *Pygidicrana*, which may be briefly described as follows:—

Female. Long. corp. 14 millim.; segm. ult. cum forcip. $5\frac{1}{2}$ millim.

Head above dull black; mouth-parts and under surface brown; antennæ brown; scape nearly black above, paler below; pronotum testaceous, with a wide brown band on each side; tegmina brown, scutellum and suture probably pale; legs testaceous; femora marbled with brown above; abdomen black, very hairy, with a pale longitudinal band covering the middle five segments on the upper side; forceps red, contiguous, unarmed.

Hab. Santarem.

This insect cannot be the immature form of any known American species, for in all these the scape of the antennæ is paler than the flagellum. I should not have described it from so poor a specimen, had it not been already on our lists under the name of *Olyntha staphylinoides*, as the supposed larva of a Neuropterous insect.

Genus IV. Thermastris, *Dohrn.*

Dohrn, Stett. ent. Zeit. xxiv. p. 61 (1863); *Scudd. Bull. U. S. Geol. Surv.* ii. p. 249 (1876).

Type, *Forficula brasiliensis*, Gray.

I do not understood why Dohrn places this genus among those with the scutellum concealed. In the three species before me (*T. brasiliensis*, Gray, *T. Saussurei*, Dohrn, and *T. chontalia*, Scudd.) the exposed scutellum is as large as in *Pygidicrana*. It is true that the scutellum is concealed in Serville's figure of his *Pyragra fuscata*; but I cannot follow De Bormans in placing *Thermastris* as a synonym of *Pyragra*.

Genus V. Cylindrogaster, *Stål.*

St°l, Œfv. Vet.-Akad. Förh. xii. p. 350 (1855).

Type, *C. gracilis*, Stål, from Rio Janeiro.

In this curious little genus I have two species to describe, one Eastern and one Western.

Cylindrogaster nigriceps, sp. n.

Long. corp. 11 millim.; segm. ult. cum forcip. 3 millim.

Head deep black, a groove within each eye, running to the occiput; clypeus black, shining; labrum transverse, pale yellow, as are also the palpi; neck yellow; antennæ 19-jointed, chocolate-brown, scape black; pronotum half as long again as broad, black, with the hind border broadly pale yellow, this colour curving up the sides nearly to the broadest part of the pronotum; scutellum reddish brown, with a yellow dot at the extremity; tegmina reddish brown, the costa rather broadly black; visible part of the wings yellow, with a large dusky spot before the extremity; abdomen reddish brown, terminal segment black and shining, forceps reddish towards the extremity; legs yellow; femora and tibiæ broadly black in the middle.

Hab. Hong Kong.

Cylindrogaster Jansoni, sp. n.

Long. corp. 10 millim.; segm. ult. cum forcip. 3 millim.

Male. Head shining black, a strong lateral ridge behind the eyes, and extending at nearly right angles across the occiput; palpi tawny; antennæ with the scape black, and the flagellum

tawny, gradually darkening, and clothed with very short hairs; joint 2 transverse, joints 3 and 5 about twice as long as broad, joint 4 shorter and joint 6 longer; joints 3–6 are pear-shaped, though 4 is rather truncated at the base; joints 7–12 are longer, more slender, and linear, but slightly rounded at each end; the rest are wanting; pronotum and base of tegmina luteous, the sides and back of the pronotum paler, rounded, and raised; legs luteous, knees broadly black; tegmina black, except at base, with a few long white bristles near the edges; wings whitish, tipped with black, on the black portion stand several long white bristles; abdomen reddish, the segments well separated; forceps very stout, contiguous, triquetral, regularly denticulated and hairy on the inner edge, slightly raised towards the tips; the extreme points are turned inwards almost at a right angle.

Hab. Chontales, Nicaragua.

Genus VI. Diplatys, *Serv.*

Serv. Ann. Sci. Nat. xxii. p. 50 (1831); *Orth.* p. 50 (1839).

Type, *Forficula macrocephala*, Beauv., from Benin.

Unrepresented in the British Museum collection.

Genus VII. Nannopygia, *Dohrn.*

Dohrn, Stett. ent. Zeit. xxiv. p. 60 (1863).

Type, *N. Gerstaeckeri*, Dohrn, from Ceylon.

Nannopygia Dohrni, sp. n.

Long. corp. 10 millim.; segm. ult. cum forcip. 2½ millim.

Female. Blackish or dark brown, very shining; tegmina purplish, scutellum distinct, abdomen reddish, wings not visible; antennæ at least 13-jointed, brown, joints 1–3 yellowish, and 13 and extremity of 12 whitish; legs testaceous, femora ringed with black; abdomen punctured, segments 2 and 3 with small lateral tubercles, terminal segment large, quadrate; forceps broad, cultriform, subcontiguous, denticulated on the inner edge, and rather abruptly hooked at the tip.

Hab. Ceylon.

Genus VIII. Echinosoma, *Serv.*

Serv. Orth. p. 34 (1839); *Dohrn, Stett. ent. Zeit.* xxiv. p. 63 (1863).

Type, *Forficula afra*, Beauv., from S. Africa.

Includes several other African and Oriental species.

Echinosoma Forbesi, sp. n. (Plate XII. fig. 9.)

Long. corp. 11–14 millim.

Black, setose, moderately broad. Head with a crescent-shaped depressed line on the vertex behind the eyes; labrum and palpi pale yellow. Antennæ with upwards of 25 joints (apparently not quite complete), first two joints pale yellow, the rest chocolate-brown; scape dilated, $1\frac{1}{2}$ times longer than broad, 3rd joint slender, at least twice as long as broad, joints 2, 4, 5, 6, 7 about as long as broad, the rest rather longer; pronotum rather variable, median line generally pale, a pale spot on the lateral margins, between which and the median line is often a smaller and yellower one, towards the extremity; tegmina with 2 tawny or yellowish dashes near the base, on each side, one near the suture and another on the side; exposed part of the wings pale yellow, but the greater part filled up, except at the base and at the extreme margins, by a large black blotch, longest near the suture; abdomen with the segments narrowly edged behind with a red line, from which 6 short, straight, red dashes project; forceps dull red; legs pale yellow, the femora, except at the tips, and a wide band at the base of the tibiæ, black.

Hab. Dinner Island (*H. O. Forbes*).

Described from four females and one male. The male is greyer, more strongly punctured, and rather more obscurely marked, and the forceps are curved instead of straight; otherwise there is but little difference in the sexes.

Allied to *E. yorkense*, Dohrn, and to *E. sumatranum*, De Haan.

Genus IX. Pyragra, *Serv.*

Serv. Ann. Sci. Nat. xxii. p. 31 (1831); *Orth.* p. 32 (1839).

Type, *P. fuscata*, Serv., from Cayenne.

This genus has some resemblance to *Thermastris*, with which De Bormans unites it; but seems to differ by its more slender form and concealed scutellum. It is perhaps more nearly related to *Labidura*. It is unknown to me except from Serville's description and figure of the type.

Genus X. LABIDURA, *Leach.*

Leach, Edinb. Encycl. ix. p. 118 (1815); *Dohrn, Stett. ent. Zeit.* xxiv. p. 309 (1863); *Scudd. Bull. U. S. Geol. Surv.* ii. p. 250 (1876).

Type, *Forficula riparia*, Pall. (*gigantea*, Fabr.).

Forficesila, *Serv. Ann. Sci. Nat.* xxii. p. 32 (1831); *Orth.* p. 21 (1839).

LABIDURA RIPARIA, *Pall.*

Forficula riparia, *Pall. Reise*, ii. *Anhang*, p. 30 (1773).

Hab. Cosmopolitan.

I believe that the description of the unrecognized *Forficula herculeana*, Fabr., from St. Helena, was probably taken from a dark or discoloured specimen of this insect, which is said to attain to a very large size in the island mentioned.

LABIDURA (?) PUGNAX, sp. n. (Plate XII. fig. 1.)

♂. Long. corp. 42 millim.; segm. ult. cum forcip. 20 millim.

♀. Long. corp. 25 millim.; segm. ult. cum forcip. 9 millim.

Male. Black, clothed with a fine greyish silky pubescence; antennæ, clypeus, palpi, head and thorax beneath, sides and hind borders of pronotum, sutural and marginal edges of tegmina (very narrowly), and those of the exposed part of the wings (narrowly) reddish; legs uniformly testaceous. Abdomen finely granulated, segments 2–5 with very strong lateral spines, basal segment with smaller ones, hinder edges of segments 3–5 milled above only, terminal segment smooth, much depressed in the middle; forceps very large, smooth, very slightly dentated on the inner sides, a triangular elevation at the base of the upper carina, a strong tooth on the inside at about one fourth of the length of the forceps, which are wide apart at the base, and run slightly curving outwards for two-thirds of their length, when they suddenly curve inwards and almost meet in an obtuse projection, thence they run nearly straight, but slightly converging to the hooked tips, which cross.

Female similar, but the abdomen is neither spiny nor milled, and the forceps simply curve outwards and then inwards, in a weaker hook than in the male; they are more strongly and thickly denticulated on the inner edge than in the male, and at about three-fourths of their length there is a small tooth pointing obliquely downwards.

Hab. North India.

There are several Indian species of spiny Earwigs which should, no doubt, form a distinct genus; but the only specimens before me are the somewhat defective pair from which the above description has been drawn up. The remaining joints of the antennæ are longer than in typical *Labidura.*

LABIDURA (?) DECIPIENS, sp. n.

Long. corp. 14 millim.; segm. ult. cum forcip. $5\frac{1}{2}$ millim.

Male. Rufo-testaceous; antennæ at least 22-jointed, the end of the scape and all the joints beyond the third brown; joint 2 transverse, 3 fully twice as long as broad, linear, 4 oval, only half as long again as broad, 5 and 6 successively longer, 3 and 5 being about equally long, the remainder linear, very long; head with the vertex red and the mouth-parts pale; pronotum nearly twice as long as broad, dull pale testaceous on the sides and behind, the hinder part dusky in the middle, forming the commencement of a blackish band on the suture of the tegmina and wings, which are straw-coloured, bordered outside with blackish; tegmina only about twice as long as the pronotum, and wings about half as long; legs testaceous, femora shading into pale red; abdomen dull red, strongly punctured, 2nd segment with conspicuous lateral tubercles; terminal segment with 4 rather conspicuous teeth at the extremity in the middle, and smaller ones on the sides; pygidium broad, but not conspicuous; forceps rather wide apart at the base, gradually incurved and meeting at the tips, a strong black-tipped tooth about the middle, and another at three-fourths of the length of the forceps; before the first is a row of small teeth, one near the base, three near the middle tooth, and several between, coalescing into a ridge.

Hab. Assam.

This curious species will form a new genus when it is better known. Although best placed with *Labidura* for the present, it has a striking resemblance to *Sphingolabis africana*, Dohrn, *S. suturalis*, Serv., &c. Lateral tubercles do not occur in typical *Labidura.*

LABIDURA GRANULOSA, sp. n.

Long. corp. 32 millim.; segm. ult. cum forcip. 14 millim.

Male. Dark reddish brown, granulated, the head very finely, the pronotum, tegmina, wings, and abdomen more coarsely; head, wings, and abdomen inclining to reddish; antennæ (of which 20

joints remain) brown above, inclining to testaceous at the base and beneath; legs testaceous; pronotum black, the lateral margins testaceous; tegmina nearly black, the suture with a rusty-red band; wings and abdomen darker reddish brown, the two penultimate segments of the latter nearly black; terminal segment very large, gradually but distinctly widening from the base to the extremity, depressed in the middle, with no terminal spines, but with a small prominence on each side at the base of the forceps; pygidium rather more prominent than in *L. riparia*, and cut off square at the extremity; forceps rather stout, especially at the base, shaped nearly as in *L. riparia*; a small tooth on the lower carina at one-third of the length of the forceps, and a larger one on the inner curve at two-thirds.

Hab. Philippines.

Allied to *L. riparia*, but a very large dark species, with the terminal segment of the abdomen differently constructed.

LABIDURA PLUVIALIS, sp. n.

Long. corp. 27 millim.; segm. ult. cum forcip. 11 millim.

Male. Black, the antennæ, mouth-parts, under surface of the head, pectus, sides of the abdomen, and legs testaceous or tawny; sides of pronotum and of tegmina, suture of the latter and terminal segment of abdomen, including forceps, reddish; a black dash on the sides of the pronotum below the pale lateral ridge; abdomen thickly and finely punctured, more coarsely below than above, terminal segment with a slight hump on each side above the base of the forceps, and a depression on the median line followed by one projecting tooth in the middle; forceps rather stout, smooth, with a small tooth projecting obliquely downwards at three-fourths of their length, and the tips, which shade into blackish, are upcurved.

Hab. Raine Island.

Allied to *L. riparia*, Pall., but the tegmina are more rounded at the tips, the wings are absent or concealed, and the abdomen ends in one middle spine instead of two.

LABIDURA (?) CLARKI, sp. n.

Long. corp. 20 millim.; segm. ult. cum forcip. 7 millim.

Female. Head smooth, red; mouth-parts, antennæ, and legs pale yellow; antennæ 20-jointed, sparingly clothed with short erect hairs, the space widened, joint 2 transverse, joint 3 twice as

long as broad, joints 4–6 hardly longer than broad, but those beyond the 4th gradually lengthening and growing rather more slender; the joints towards the tip about 4 times as long as broad, and the last joint half as long again as any of the preceding. Pronotum blackish, the raised margins and a central line ferruginous. Tegmina coriaceous, the suture ferruginous, and the outer edge yellowish; exposed portion of wings one-third as long as the tegmina, coarsely reticulated, dark brown, slightly bordered with yellowish; scutellum slightly exposed. Abdomen reddish brown, paler beneath and on the sides; last joint rather short, with a slight protuberance on each side above the base of the forceps, which are long, blackish, slightly varied with reddish, nearly straight, unarmed, and slightly upturned and incurved at the extremity.

Hab. Rio Janeiro (collected by the late Rev. Hamlet Clark).

LABIDURA MOROSA, sp. n.

Long. corp. 21 millim.; segm. ult. cum forcip. 7 millim.

Female. Black; antennæ, mouth-parts, lateral borders of pronotum, and wings castaneous; legs paler; forceps dark red, broad and approximating at the base and meeting at the tips, a very strong carina on the upper surface, the inner and lower edge denticulated (most strongly towards the base) as far as a very strong tooth at about five-sixths of their length.

Hab. —— ?

Not closely allied to any known species. I usually refrain from describing species of unknown locality, but in this insect the form of the forceps is so unusual as to allow of its being recognized at once.

Genus XI. DEMOGORGON, g. n.

Male. Head convex, as broad or rather broader than the prothorax behind; antennæ with about 30 joints, scape widened, joints 2, 4, 5 rounded, the rest oblong and gradually increasing in length to about the middle, beyond which they are slender and of about equal length.

Pronotum half as long again as broad, slightly depressed across the middle, with raised margins, the hinder part somewhat raised and widened.

Elytra truncated behind; wings absent or concealed.

Abdomen long, slightly widened beyond the middle, the dorsal segments gradually diminishing in length to the 7th; 5th and 6th as if milled on the hind border; terminal segment very large, nearly square, slightly humped above the inner base of the forceps but without teeth; on the ventral surface it slopes backward, so that the penultimate ventral segment, which is subtriangular and reaches nearly to the extremity of its ventral portion, not only leaves the sides widely uncovered, but also that part of the lower surface, really belonging to the dorsal portion, which slopes backwards between the base of the forceps.

Forceps rather long and stout, widely separated at the base, with several blunt teeth beyond the middle, and curved upwards.

Legs moderately long and slender, clothed with short hairs; first joint of the tarsi densely hairy beneath; front femora rather shorter and stouter than the others.

Female with the forceps long, contiguous, unarmed, slightly upcurved, and crossed at the extremity.

Allied to *Labidura*; type *D. Batesi*, sp. n., but will also include *L. livida*, Dubr., and some other American species.

DEMOGORGON BATESI, sp. n. (Plate XII. figs. 3, 3 *a*.)

Long. corp. 36 millim.; segm. ult. cum forcip. 15 millim.

Male. Yellowish, the front of the body inclining to grey, the abdomen to tawny; mandibles blackish; tegmina with the suture shading into tawny. Abdomen with the segments finely punctured towards the extremity, segments 5 and 6 very strongly milled; last segment smooth above, with a depressed line on the middle; segments 2–7 above and beneath blackish in the middle towards the extremities, and segments 3–6 are also blackish on the upper part of the sides; forceps shading into blackish towards the extremity.

Hab. Santarem.

Closely allied to *D. livida*, Dubr., though nearly twice the size; but the eyes are unicolorous, whereas in *D. livida* they are deep black.

DEMOGORGON BICOLOR, sp. n.

Long. corp. 29 millim.; segm. ult. cum forcip. 10 millim.

Male. Luteous, inclining to reddish; head beneath, pectus, and base and sides of the abdomen paler. Eyes black. Pro-

notum with a black stripe on each side within the raised margins, tapering and ceasing before the hind margin. Hinder raised part of the pronotum, and tegmina coriaceous. Tegmina black, the suture with a reddish band, tapering, but extending quite to the extremity. Hinder half of the abdomen (the terminal segment excepted) reddish above and below in the middle, shading into blackish towards the ends of the segments, punctured, and in segments 3 and 6 above, and in 4 and 5 below, longitudinally ridged or milled; terminal segment and forceps luteous, the former with a depression on the median line above, and with slightly reddish tubercles above the base of the forceps. Hinder half of the forceps shading into dark red.

Hab. South America (precise locality unrecorded).

DEMOGORGON ADELPHUS, sp. n.

Long. corp. 25 millim.; segm. ult. cum forcip. 10 millim.

Male. Luteous tawny; antennæ (which are about 30-jointed), eyes, and under surface paler. Pronotum finely coriaceous; tegmina more closely so, and covered with small tubercles close together. Pronotum black above, the neighbourhood of the median line irregularly reddish, the lateral margins edged with a narrow pale line. Tegmina black, the lateral margins edged with a very narrow pale line; a tapering reddish band on the suture, hardly reaching the extremity. Abdomen with most of the segments (except the terminal one) blackish in the middle above and below; segments 4 and 5 below, and 5 and 6 above milled, segment 7 very narrow above, almost obsolete; terminal segment and forceps as in *D. bicolor.*

Hab. Brazil (Catagallo).

DEMOGORGON PATAGONICUS, sp. n. (Plate XII. fig. 2.)

Long. corp. 23 millim.; segm. ult. cum forcip. 8 millim.

Female. Tawny; head reddish above, eyes black; antennæ 23-jointed; pronotum reddish, with a wide black band on each side, very narrowly edged with pale outside, and curving inwards at the extremity; tegmina similarly coloured, the red band on the suture regularly narrowing behind; abdomen with most of the segments blackish in the middle above and reddish below, finely punctured above, and more coarsely beneath, but not milled; forceps reddish, paler at the base above, and blackish

towards the tips, which are incurved, crossed, and slightly raised. At the base they are subcontiguous; the inner edge is denticulated.

Hab. Patagonia.

Possibly the female of one of the foregoing species.

Genus XII. Psalis, *Serv.*

Serv. Ann. Sci. Nat. xxii. p. 84 (1831); *Burm. Handb. Ent.* ii. p. 753 (1839); *Scudd. Proc. Bost. Soc. Nat. Hist.* xviii. p. 297 (1876); *Bull. U. S. Geol. Surv. Territ.* ii. p. 250 (1876).

Type, *Forficula americana*, Beauv., from Tropical America.

Psalis (?) picina, sp. n.

Long. corp., ♂ 12½ millim., ♀ 10 millim.; ♂ ♀, segm. ult. cum forcip. 3 millim.

Pitchy; head, tegmina, and forceps inclining to reddish; abdomen (and pronotum in the male) darker; antennæ 19-jointed, brown, paler beneath; joints 1, 2, 17, and 18 in ♂, 1, 2, 16, and 17 in ♀ whitish; pronotum nearly twice as long as broad in the male, shorter in the female, the lateral margins testaceous; wings narrowly bordered with testaceous on each side at the base and along the suture; legs testaceous; abdomen punctured; forceps contiguous, gradually curved, and crossing at the extremities, denticulated on the inner edge.

Hab. Gambia.

Much resembles *Labidura rufescens*, Beauv.; but this species is described as having at least 30 joints to the uniformly pale antennæ.

Genus XIII. Labidurodes, *Dubr.*

Dubr. Ann. Mus. Genov. xiv. p. 385 (1879).

Type, *L. robustus*, Dubr., from Papua.

Not represented in the Museum Collection.

Genus XIV. Anisolabis, *Fieb.*

Fieb. Lotos, iii. p. 257 (1853); *Scudd. Bull. U. S. Surv. Territ.* ii. p. 251 (1876).

Forcinella, *Dohrn, Stett. ent. Zeit.* xxiii. p. 226 (1862), xxv. p. 285 (1864).

Brachylabis, p., *Dohrn, l. c.* xxv. p. 292 (1864).

Type, *Forficula maritima*, Géné, from Europe.

Labidura advena, Mein., from Jamaica, proves to belong to this genus.

ANISOLABIS RUFESCENS, sp. n. (Plate XII. fig. 10.)

Long. corp. 29 millim.; segm. ult. cum forcip. 9 millim.

Male. Head red, black above in front, and the red part behind marked with several black lines to the occiput; a red spot on each side of the vertex, within each eye; clypeus brown, bordered with yellowish; mandibles and extremity of the labrum red; antennæ 21-jointed; scape reddish; flagellum yellowish brown, thickly clothed with short diverging hairs; pronotum red; basal segments of abdomen red above, and bordered with blackish behind; beneath, the rest of the abdomen and the forceps black, thickly and finely punctured, more coarsely punctate-striate on the sides; forceps thick, broadened beyond the base, but without a basal tooth; the inside of the curve denticulated, the right side rather more curved and shorter than the left; legs reddish, rather paler than the thorax; pygidium exposed, bifid at the extremity.

Hab. Cameroons.

Apparently allied to *A. mauritanica*, Luc., but much larger and differently coloured.

ANISOLABIS XENIA, sp. n.

Long. corp. 22–25 millim.

Dark chestnut-brown, more or less inclining to red; antennæ and legs testaceous; femora distinctly brownish before the tips; forceps very stout, crossed, the right one in the ♂, as usual, shorter and more curved; ♂ with two, ♀ with three, large triangular teeth on the inside between the base and the middle.

Hab. Norfolk Island.

Allied to *A. littorea*, White, from New Zealand.

ANISOLABIS ANTENNATA, sp. n.

Long. corp. 9 millim.; segm. ult. cum forcip. 2 millim.

Female. Reddish brown above; the forceps, which are rather long and crossed at the tips, redder; under surface pale, but darkening beyond the middle of the abdomen, towards the red forceps; antennæ brown, the joints spotted with pale at the base and tip, and joints 1, 2, and 12 entirely pale (the rest broken off), hind femora pale brown in the middle.

Hab. Bermuda.

Possibly a variety of *A. azteca*, Dohrn; but in that species the femora are more distinctly ringed with fuscous, and the 9th joint of the antennæ is pale. However, De Bormans mentions a specimen from Palmal, which he considers to be a variety of *A. azteca*, in which joints 1, 2, 10, and 11 are whitish.

Genus XV. BRACHYLABIS, *Dohrn*.

Dohrn, *Stett. ent. Zeit.* xxv. p. 292 (1864); *De Borm. Ann. Soc. Ent. Belg.* xxvii. p. 64 (1883).

Type, *Forficula chilensis*, Blanch., from Chili.

Not represented in the Museum Collection.

Genus XVI. PLATYLABIA, *Dohrn*.

Platylabia, *Dohrn*, *Stett. ent. Zeit.* xxviii. p. 347 (1867).

Labidophora, *Scudd. Proc. Bost. Soc. Nat. Hist.* xviii. p. 297 (1876).

Type, *P. major*, Dohrn, from Celebes.

PLATYLABIA NIGRICEPS, sp. n.

Long. corp. 10 millim.; ult. segm. cum forcip. 3 millim.

Male. Luteous; head, except the mouth-parts and under surface, tegmina, except at the base, and wings shining black; abdomen darkening into reddish, the hinder edge and forceps blackish, the latter reddish towards the tips; the whole body set with long pale divergent hairs, most distinct on the antennæ and forceps; tegmina and wings coriaceous; abdomen finely and thickly punctured; pygidium nearly square, with slightly projecting hinder angles, and a projection in the middle; forceps long, nearly straight, but converging at the tips; on the inner side there is a strong tooth about the middle.

Hab. Dorey.

Resembles *P. thoracica*, Dohrn, in shape, size, and general appearance.

Genus XVII. CHÆTOSPANIA, *Karsch*.

Karsch, *Berl. ent. Zeitschr.* xxx. p. 87 (1886).

Type, *C. inornata*, Karsch, from Madagascar.

Not in the Museum Collection.

Genus XVIII. Sparatta, *Serv.*

Serv. Orthoptères, p. 51 (1839).

Type, *S. pelvimetra*, Serv., from Brazil.

Sparatta Horsfieldi, sp. n.

Long. corp. 12 millim.; segm. ult. cum forcip. 4 millim.

Female. Dull red or tawny; head light red, smooth, with the occipital suture well-marked; antennæ at least 14-jointed, black, 2nd joint transverse, the rest oval or pear-shaped, set with short diverging hairs, scape light red, joints 11 and 12 pale; head somewhat concave behind; prothorax forming a distinct neck, the anterior angles being strongly marked; pronotum brown in front and tawny yellow behind; tegmina varying from brown to tawny according to the light; wings darker, with the edges narrowly pale; legs (as well as the head and pectus) luteous tawny; abdomen dull reddish, blackish on the sides at the base; extremity also blackish; forceps light red, gradually incurved and meeting at the points, the inner edge regularly denticulated; pygidium yellowish, very wide and short, and concave at the extremity.

Hab. Java.

Not closely allied to any described species.

Genus XIX. Mecomera, *Serv.*

Serv. Orth. p. 53 (1839).

Type, *M. brunnea*, Serv., from S. America.

Not represented in the Museum Collection.

Genus XX. Labia, *Leach.*

Leach, Edinb. Encycl. ix. p. 118 (1815); *Dohrn, Stett. ent. Zeit.* xxv. p. 423 (1864); *Scudd. Bull. U.S. Geol. Surv. Territ.* ii. p. 257 (1876).

Type, *Forficula minor*, Linn., from Europe.

Labia buprestoides, sp. n. (Plate XII. fig. 8.)

Long. corp. 13–16 millim.; segm. ult. cum forcip. 5–6 millim.

Head and abdomen, except the terminal segment, black; antennæ 16-jointed, brown, clothed with short hairs; pronotum and tegmina metallic green, the former less intense and slightly tinged with coppery at the edges; wings white, the exposed part

metallic green, except a conspicuous spot at the base and a narrow edging; legs testaceous; femora black, spotted with testaceous, or with the whole of the grooved under surface testaceous; tibiæ with two black spots above; terminal segment of abdomen and forceps luteous, the latter blackish and crossed at the tips. Forceps wide apart in the male, with a small tooth on the inner edge at the base, thence regularly denticulated to four-fifths of their length where there is a much larger triangular tooth. Forceps in the female more strongly but irregularly denticulated, and without the two larger teeth present in the male. The pygidium is not distinctly visible in any of the three specimens before me.

Hab. Ega.

Probably allied to *L. chalybea*, Dohrn.

This species, which is one of the largest of the genus, clearly mimics some metallic beetle belonging either to the *Buprestidæ* or to the *Staphylinidæ*.

LABIA (?) GLABRICULA, sp. n.

Long. corp. 5 millim.; segm. ult. cum forcip. 1½ millim.

Male. Head, pronotum, tegmina, and wings shining black, finely punctured; mouth-parts and 10-jointed antennæ dull tawny; abdomen dark chestnut-brown, becoming reddish towards the extremity and on the forceps; pronotum rounded behind, subquadrate, the lateral margins testaceous; tegmina twice as long as broad; wings rather pointed; abdomen rather broad, reddish brown, rather coarsely punctured, last segment and forceps red; the latter rather wide apart at base, but curving sharply inwards and crossing at the tips; they are smooth, with scattered pale yellow hairs, and one tooth near the base.

Hab. Santarem.

Possibly allied to *L. arcuata*, Scudd.

LABIA TRICOLOR, sp. n.

Long. corp. 4½ millim.; segm. ult. cum forcip. 2 millim.

Male. Head shining black; mouth-parts, 10-jointed antennæ, and legs rufo-testaceous; pronotum, tegmina, and wings purplish brown; abdomen reddish; forceps rather long, subparallel, but touching at the tips, denticulated on the inner edge; pygidium long and narrow, one third as long as the forceps, and bifid at the extremity.

Hab. Santarem.

Genus XXI. Spongophora, *Serv.*

Spongiphora, *Serv. Ann. Sci. Nat.* xxii. p. 31 (1831).

Spongophora, *Agass. Nom. Zool.* p. 349 (1846); *Scudd. Bull. U.S. Geol. Surv. Territ.* ii. p. 251 (1876).

Psalidophora, *Serv. Orth.* p. 29 (1839); *Dohrn, Stett. ent. Zeit.* xxv. p. 417 (1864).

Type, *S. croceipennis*, Serv., from Brazil.

Spongophora Dysoni, sp. n. (Plate XII. fig. 6.)

Long. corp. 20 millim.; segm. ult. cum forcip. 9 millim.

Female. Head blackish above; the mouth-parts and occiput reddish; antennæ at least 17-jointed, tawny; pronotum dark brown, the lateral carinæ paler; tegmina chestnut-brown, emarginate at tips; exposed part of wings luteous, bordered with chestnut; terminal segment of abdomen tawny, with some obsolete, brown, longitudinal stripes above, strongly punctured towards the extremity; pygidium emarginate, and therefore distinctly bifid; forceps long, gradually curved, thickened towards the base and very slightly denticulated, meeting at the tips; legs straw-coloured, femora striped both above and below with brown; body beneath testaceous, sides of abdomen darker.

Hab. Venezuela.

A comparatively short and stout species; it most resembles an insect from Theresopolis, which may be the female of *S. lheriminieri*, Serv., or *S. flavipennis*, Burm., which are probably distinct from *S. croceipennis*, Serv. This, too, has the terminal segment and forceps pale.

Genus XXII. Chelisoches, *Scudd.*

Scudd. Proc. Bost. Soc. Nat. Hist. xviii. p. 295 (1876).

‖ Lobophora, *Serv. Orth.* p. 32 (1839).

Type, *Forficula morio*, Fabr., from the Eastern Archipelago.

Chelisoches tenebrator, sp. n. (Plate XII. fig. 5.)

Long. corp. 25 millim.; segm. ult. cum forcip. 10 millim.

Female. Chestnut-brown, forceps and abdomen beneath reddish; antennæ 18-jointed, the second transverse, all the rest much longer than broad, but the 4th distinctly shorter than the 3rd and 5th; joint 12 (except at base), and joints 13 and 14 entirely

straw-colour; front of pronotum with three depressed lines in the middle, beyond which is a long hump on each side; wings well developed. Abdomen finely punctured, segment 7 milled at the extremity, above, last segment comparatively short; pygidium strong, truncated; forceps smooth, very slightly curved outwards in the middle, a strong tooth on the inside at the base, and one or two very small ones in the middle, tips incurved.

Hab. India.

Allied to *C. morio*, Fabr.

CHELISOCHES (?) PICTICORNIS, sp. n. (Plate XII. fig. 4.)

Long. corp. 22 millim.; segm. ult. cum forcip. 9 millim.

Male. Inky black, the lower mouth-parts and under surface of the tarsi inclining to rufo-testaceous; antennæ with the first six joints red, joints 7–9 black, 10 white, the rest wanting; pronotum quadrate, a little longer than broad; tegmina about twice as long, and wings extending beyond them for a distance about one third of the length of the tegmina; the greater part of the body finely coriaceous; base of the segments of the abdomen with large, distant, shallow pits, 2nd and 3rd segments tuberculate on the sides; pygidium rather broad, subtruncated; forceps as long as the abdomen, distant at base, smooth, curving gradually outwards and inwards, towards the base depressed and keeled, and with a moderately strong triangular tooth about the middle.

Hab. Philippines.

This insect is probably the male of *Forficula lobophoroides*, Dohrn.

Genus XXIII. AUCHENOMUS, *Karsch.*

Auchenomus, *Karsch, Berl. ent. Zeitschr.* xxx. p. 89 (1886).

Type, *A. longiforceps*, Karsch, from Madagascar.

Not represented in the Museum Collection.

Genus XXIV. NEOLOBOPHORA, *Scudd.*

Scudd. Proc. Bost. Soc. Nat. Hist. xvii. p. 281 (1875); *Bull. U.S. Geol. Surv. Territ.* ii. p. 253 (1876).

Type, *N. volsella*, Scudd., from Mexico.

Genus XXV. Ancistrogaster, *Stål.*

Stål, Œfv. Vet.-Akad. Förh. xii. p. 349 (1855); *Scudd. Bull. U.S. Geol. Surv.* ii. p. 253 (1876); *Proc. Bost. Soc. Nat. Hist.* xviii. p. 288 (1876).

Type, *A. luctuosus*, Stål, from Brazil.

There is a single specimen of a new species from Australia in the Museum Collection, with lateral hooks on the abdominal segments, as in *Ancistrogaster*, but differing much in the shape of the body and forceps. I forbear to describe it, as it must belong to a new genus, and I prefer to wait till more specimens are obtained.

Genus XXVI. Opisthocosmia, *Dohrn.*

Dohrn, Stett. ent. Zeit. xxvi. p. 76 (1865).

Type, *O. centurio*, Dohrn, from the Indo-Malayan Islands.

Opisthocosmia humeralis, sp. n.

Long. corp. 11 millim.; segm. ult. cum forcip. 4 millim.

Female. Pitchy brown; head dull red; antennæ at least 11-jointed, all the joints beyond the 4th cylindrical and very long; 3 and 4 rather thicker, and together not much longer than any of the following ones, being about twice as long as broad; antennæ blackish, joint 10 whitish except at the base; pronotum black, narrower than the head and rounded behind; its lateral margins, the legs, a broad band on the basal half of each of the tegmina, and a large basal spot on the nearly black wings, luteous; abdomen with the 2nd segment laterally tuberculate; forceps half as long as the abdomen, slightly thickened at the base and very slightly denticulated on the inner edge, gradually curved, and meeting at the tips.

Hab. Ceylon.

Allied to *O. centurio*, but smaller and differently coloured.

Opisthocosmia (?) cervipyga, sp. n. (Plate XII. figs. 12, 12 *a.*)

Long. corp. 17 millim.; segm. ult. cum forcip. 7½ millim.

Male. Black; eyes red; mouth-parts, the long inferior spine of the forceps and the tip mostly red; antennæ pubescent, with long joints, joint 7 white except at the base (the remaining joints wanting); vertex smooth; occiput reddish brown, it is separated

off by a deep channel running between the eyes and, as well as the vertex, is slightly depressed on the median line; pronotum oblong, channelled in front, the sides and the hinder lobe raised; tegmina and wings dull black, the latter very narrowly edged outside with reddish; the projecting part about one third as long as the tegmina; legs very long, ferruginous; femora reddish brown. Abdomen very finely punctured, narrow at the base, but widely expanded beyond, the first 4 segments tuberculated on the sides, the terminal segment with the extremity depressed, with 2 slight elevations at the base of the forceps, and the hinder edge raised. Forceps stout, raised, diverging, and then converging; they first form a short curve upwards, and then a much longer one at almost a right angle downwards; about the curve is a short strong spine directed backwards; beneath they are slightly denticulated towards the base; the long downward curves end in long, sharp, slightly incurved spines, above which the forceps rise again in short rounded curves, ending beneath in shorter spines; and they then rise again to form curved terminal spines, the tips of which touch.

Hab. Sarawak.

Very similar to *Forficula longipes*, De Haan, but much larger; and in *F. longipes* ♂ only the first two abdominal segments are tuberculated; the species likewise differ in colour and in the shape of the forceps.

Genus XXVII. Anechura, *Scudd.*

Scudd. Proc. Bost. Soc. Nat. Hist. xviii. p. 289 (1876).

Type, *Forficula bipunctata*, Fabr., from Europe.

This species is included by Dohrn in his first section of *Forficula*; but few of the other species which he places with it are congeneric with either *Forficula* or *Anechura*. Several new genera will ultimately be required for their reception; but for the present they may be temporarily associated with *Sphingolabis*.

Genus XXVIII. Forficula, *Linn.*

Linn. Syst. Nat. i. p. 423 (1758); *Serv. Orth.* p. 35 (1839); *Dohrn, Stett. ent. Zeit.* xxvi. p. 84 (1865).

Type, *F. auricularia*, Linn., from Europe.

This genus must be restricted to those species in which, as in

F. auricularia, the forceps are flattened and contiguous at the base in the male and diverge afterwards.

FORFICULA CORIACEA, sp. n.

Long. corp. 11 millim.; segm. ult. cum forcip. 3 millim.

Female. Rufo-testaceous; head dark reddish brown; tegmina and wings purplish brown, except the base of the former; tips of front femora and all the tibiæ and tarsi brown, as is also the scape of the antennæ (the rest wanting); last two segments of the abdomen shining black above, beneath more inclining to reddish; forceps black, with a pale spot at the base of each, and the tips inclining to reddish; the latter are simple, slightly incurved and upturned. The insect is set with short hairs and is finely coriaceous. The second segment of the abdomen is laterally tuberculate, and the terminal segment is unusually long, and its upper extremity ends in a concave carina.

Hab. Sierra Leone.

A peculiar species, not closely allied to any other, and easily recognizable by the dark head and apical segments.

FORFICULA PICTA, sp. n.

Long. corp. 8–9 millim.; segm. ult. cum forcip. 2–3 millim.

Antennæ chocolate-brown, scape yellow; head yellow (chocolate-brown above in the male); tegmina obliquely divided, the basal and outer half being yellow and the inner and hinder half chocolate-brown; pectus, legs, and wings wholly yellow; abdomen reddish-chocolate; forceps of male widened and contiguous at base, gradually curving beyond to meet at the tips, unarmed; those of the female contiguous throughout and crossing at the tips; pronotum slightly longer than broad, rounded behind; abdomen moderately punctured, the 2nd and 3rd segments tuberculate.

Hab. Zululand.

FORFICULA PLANICOLLIS, sp. n.

Long. corp. 11 millim.; segm. ult. cum forcip. 4 millim.

Female. Head and abdomen castaneous; pronotum black, the lateral margins, tegmina, and wings testaceous; abdomen thickly and coarsely punctured; forceps rather long, subcontiguous, nearly straight, but meeting at the tips.

Hab. North India.

Allied to *F. auricularia*, Linn.

Genus XXIX. Sphingolabis, *De Borm.*

De Borm. Ann. Soc. Ent. Belg. xxvii. p. 59 (table) (1883).

Type, *S. furcifera*, De Borm., from Sumatra.

This genus has never been properly characterized, and I cannot venture to do this now, because the typical species is not before me. *Sphingolabis*, however, removes from *Forficula* all the species not yet assignable to other described genera in which the male forceps are divergent at the base; and though it may now be used provisionally in this wide sense, it must later on be subdivided into numerous smaller genera.

Sphingolabis variegata, sp. n.

Long. corp. 15 millim.; segm. ult. cum forcip. 5 millim.

Female. Reddish brown, the pronotum (except the margins), the sides of the basal segments of the abdomen, and the last segment shading into blackish; antennæ at least 12-jointed, the joints comparatively short; joints 10 and 11, the lateral and hinder margins of the pronotum, and the penultimate segment of the abdomen pale testaceous; tegmina tricoloured; a broad reddish stripe on the suture, a yellowish-testaceous stripe in the middle, and the outer edge blackish; wings reddish, the borders right round to the sutural margin yellowish testaceous; legs reddish, the knees and tarsi shading into testaceous; pygidium rounded; forceps rather long, moderately stout, not closely approximating at base, unarmed, slightly incurved, and meeting at the tips.

Hab. Sierra Leone.

Somewhat resembles *S. africana*, Dohrn.

Sphingolabis bipartita, sp. n.

♂. Long. corp. 13–16½ millim.; segm. ult. cum forcip. 6–7½ millim. ♀. Long. corp. 10 millim.; segm. ult. cum forcip. 3 millim.

Head and front of pronotum pale red above; sides and hind part of pronotum pale testaceous, the two colours sometimes separated by a dusky crescent; antennæ and abdomen darker red, the lateral tubercles on the 2nd and 3rd segments of the abdomen surrounded with blackish; tegmina and wings pale yellow, the former with a reddish or brownish band on the suture hardly extending to the wings; legs pale yellow. Pronotum as broad as the head, subquadrate rounded behind; tegmina nearly three times as long as the pronotum, and wings nearly half as long

as the tegmina; head, tegmina, and wings finely coriaceous. Abdomen above covered with large depressed punctures; the last segment deeply depressed in the middle of the hinder half, with an elevation on each side; pygidium short and broad, curved at the extremity; male forceps with a very large triangular projection near the base, dentated and nearly touching at the extremity, then slightly curved outwards, afterwards gradually approximating till the hooked tips (which shade into blackish, the rest being red) meet; they are unarmed, except the projection at the base. In the female the forceps are simple, subcontiguous, and meet at the tips, where they are slightly raised.

Hab. India.

This species resembles *S. africana*, except in the large tooth near the base of the forceps in the male, which indicates a nearer affinity to typical *Forficula*.

SPHINGOLABIS (?) SUBAPTERA, sp. n.

Long. corp. 15 millim.; segm. ult. cum forcip. 5 millim.

Male. Subdepressed; head above, pronotum, tegmina, and basal half of femora black, shining, very finely punctured; antennæ at least 13-jointed, set with short raised bristles, the 3 basal joints rufo-testaceous, the remainder castaneous; face, under surface, and legs, beyond the middle of the femora, rufous; hinder and lateral edges of pronotum narrowly testaceous. Pronotum nearly square; tegmina half as long again and truncated at the extremities; wings not visible. Abdomen reddish chestnut, the sides rugose, and black above to beyond the middle; 3rd segment with very distinct tubercles, sometimes reddish; the hinder half of segment 4 and the middle segments very strongly rugose above in the centre, the others less so, and the basal and terminal segments nearly smooth; terminal segment rather large, truncated at the extremity, and slightly raised; pygidium very large, nearly of the form of a truncated isosceles triangle, but with the base suddenly widened; forceps rather thickened at the base, but widely separated, curving gradually inwards and slightly downwards and meeting at the tips; near the base is a very large sharp tooth, directed downwards and backwards, below the extremity of the pygidium; there is also a smaller tooth on the inner edge at about the middle of the length of the forceps.

Hab. Queensland.

Not closely allied to any known species, and only provisionally referred to *Sphingolabis*.

SPHINGOLABIS SPICULIFERA, sp. n. (Plate XII. figs. 7, 7 *a*.)

Long. corp. 17 millim.; segm. ult. cum forcip. 8 millim.

Male. Head dark chocolate-brown; pronotum rather narrower than the head and nearly twice as long as broad, black, lateral borders testaceous; antennæ and abdomen reddish, except the neighbourhood of the lateral tubercles on the 3rd segment of the abdomen, which is black; tegmina testaceous, with a blackish band on the suture; wings not visible; legs testaceous; head, pronotum, two basal segments of abdomen, and terminal segment (except two parallel longitudinal spaces on the back) very finely coriaceous; the rest of the abdomen with deep round punctures; pygidium not prominent, but armed with a long sharp spine, nearly two millimeters in length, projecting between the base of the forceps; forceps wide apart, thickened and diverging at base, then curving gradually downwards and upwards; just beyond the base is a rather strong tooth on the *upper* surface, and the inner curve is denticulated throughout, as far as a small tooth just before the upward turn of the tips, at about four fifths of the length of the forceps.

Hab. New South Wales.

Allied to the South-American *S. gracilis*, Burm., and *S. suturalis*, Serv.; but in these species the pygidial spine is much smaller; wings are present; and the sides of the abdomen are parallel. In *S. spiculifera* the abdomen widens considerably from the base to the extremity.

SPHINGOLABIS BINOTATA, sp. n.

Long. corp. 13 millim.; segm. ult. cum forcip. 5 millim.

Male. Head above and front of pronotum blackish; mouth-parts, scape of antennæ (all present), and legs rufo-testaceous; sides and hinder half of pronotum pale testaceous; pronotum oblong, a little longer than broad; head, pronotum, and tegmina all coriaceous; tegmina reddish chocolate, nearly twice as long as the pair together are broad; wings half as long as the tegmina, with a large yellow spot at the base, the suture red, and the tips otherwise blackish. Abdomen dull reddish, the 2nd and 3rd segments tuberculate, terminal segment blackish; pygidium dull red, longer than the last dorsal segment, and of the form of a

truncated cone, grooved above towards the extremity; forceps red, nearly as long as the exposed part of the abdomen, separated at base, unarmed, gradually curved, unusually uniform in thickness, hairy, and somewhat obtuse at the tips.

Hab. Colombia.

SPHINGOLABIS (?) PERPLEXA, sp. n.

Long. corp. 14 millim.; segm. ult. cum forcip. 6 millim.

Male. Dark chestnut; legs paler; base of femora, tarsi, and tips of wings testaceous; antennæ 9-jointed, joints 5–9 very long, terminal joint testaceous, except at base; pronotum narrower than the head, castaneous, sides testaceous; pleura black. Abdomen reddish testaceous; sides of segments 2, 3, 6, and 7 tuberculate; forceps laterally compressed, widely apart at base, slightly diverging, and curving upwards in a strong triangular tooth, thence curving inwards till they nearly touch at half their length, then angulated and running horizontally in a very slight inward curve; the pointed tips are crossed at the extremity; the inner edge is denticulated throughout its whole length; and all parts of the body of the insect are sparsely set with rather long erect bristles.

Hab. Rio.

This species does not appear to be allied to any previously described, and will doubtless be placed in a new genus when a series is obtained.

SPHINGOLABIS MERIDIONALIS, sp. n.

Long. corp. 12 millim.; segm. ult. cum forcip. 4 millim.

Male. Head above, pronotum, wings, and forceps, except at the base, blackish; antennæ at least 9-jointed, the joints, except the 2nd and 3rd, very long, sparingly pilose, rufous towards the base and blackish towards the extremity; joint 8, and sometimes the extremity of joint 7, white; sides of pronotum narrowly testaceous, and a testaceous spot at the extremity of the suture of the wings; tegmina, abdomen, and extreme base of forceps castaneous; sides of abdomen blackish towards the base, segments 2 and 3 tuberculated; legs testaceous; pygidium bowl-shaped, with a slight projection on the lower surface on each side; forceps regularly curved, denticulated towards the base, a very

strong rectangular tooth beyond the middle, and a much more obtuse prominence before the tips, which are somewhat attenuated.

Female (?). Brownish black; antennæ 13-jointed, castaneous, darker at base, vertex slightly reddish; lateral borders of pronotum, tegmina, except a broad blackish band on the suture, and legs testaceous; wings not visible; pygidium longer and narrower than in the male, triangular above, and with the projecting lateral points much more conspicuous; forceps shaped as in the male, minutely denticulated on the inner edge, but without larger teeth.

Hab. Theresopolis.

Apparently allied to *Forficula parvicollis*, Stål.

Genus XXX. Apterygida, *Westw.*

Westw. Mod. Class. Ins. ii. *Gen. Synopsis*, p. 44 (1840).

Type, *Forficula albipennis*, Charp., from Europe.

This genus will include the small subapterous European species with forceps diverging at the base in the male, which are included by some authors with *Forficula*, and by others with *Chelidura*. All the species which properly belong to *Sphingolabis* have fully developed organs of flight.

Genus XXXI. Chelidura, *Serv.*

Serv. Ann. Sci. Nat. xxii. p. 36 (1832).

Type, *Forficula aptera*, Charp., from Europe.

Genus XXXII. Carcinophora, *Scudd.*

Scudd. Proc. Bost. Soc. Nat. Hist. xviii. p. 291 (1876).

Type, *Chelidura robusta*, Scudd., from Peru.

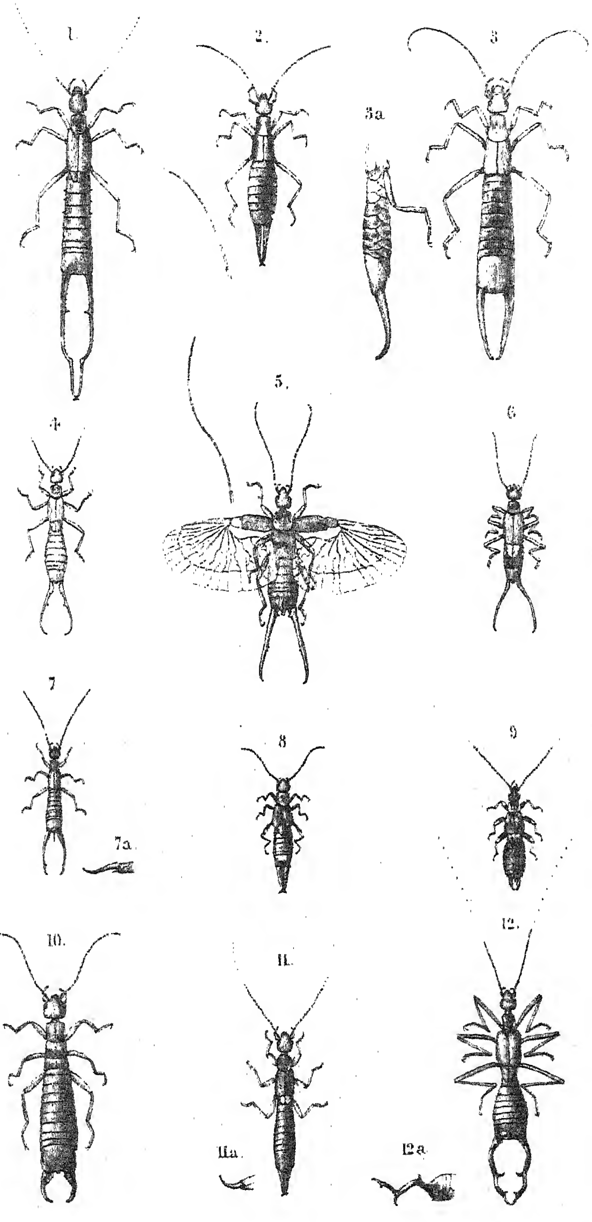
Not represented in the Museum Collection.

Doubtful Genera.

Genus XXXIII. (?) Condylopalama, *Sund.*

Sund. Forh. Skand. Naturf. iv. p. 255 (1847); *Scudd. Proc. Bost. Soc. Nat. Hist.* xviii. p. 292 (1876).

Type, *Condylopalama agilis*, Sund., from Brazil.



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NEW FORFICULIDÆ

Genus XXXIV. Typhlolabia, *Scudd.*
Scudd. Proc. Bost. Soc. Nat. Hist. xviii. p. 300 (1876).

Type, *Forficula* (?) *lævis*, Phil., from Chili.
Believed to belong to the genus *Iapyx*, Hal. (*Thysanura*).

DESCRIPTION OF PLATE XII.

Fig. 1. *Labidura pugnax.*
2. *Demogorgon patagonicus.*
3, 3 *a*. *Demogorgon Batesi.*
4. *Chelisoches* (?) *picticornis.*
5. *Chelisoches tenebrator.*
6. *Spongophora Dysoni.*
7, 7 *a*. *Sphingolabis spiculifera.*
8. *Labia buprestoides.*
9. *Echinosoma Forbesi.*
10. *Anisolabis rufescens.*
11, 11 *a*. *Pygidicrana Horsfieldi.*
12, 12 *a*. *Opisthocosmia* (?) *cervipyga.*

On a Variety of *Alectona Millari* (Carter). By A. Vaughan Jennings, F.L.S., F.G.S., Lecturer on Comparative Anatomy to the Birkbeck Institute.

[Read 20th November, 1890.]

(Plate XIII.)

In his 'Monograph of the British Spongiadæ,' Dr. Bowerbank * figured a siliceous spicule, remarkable for its resemblance in form to that of a *Gorgonia*, as belonging to a sponge that had "never yet been determined."

Mr. Carter in 1879 † described similar spicules associated with microscleres of his sceptrella type, occurring in a homogeneous dried sarcode. The sponge appeared to be of an excavating habit, but on account of its association with *Cliona* this could not be determined with certainty. He referred it to the genus *Gummina* ‡ under the name of *G. Wallichii.*

* Vol. i. pl. xi. no. 244.
† Annals and Magazine of Natural History, 1879, vol. iii. p. 353.
‡ Written *Corticium* but corrected subsequently.

Later in the same year Mr. Carter* was able to give a full account of a specimen boring in a coral (*Amphihelia oculata*, Duncan) dredged between Scotland and the Faroe Isles. Deciding that the sponge could not remain in the genus *Gummina*, he substituted for the name previously given that of *Alectona Millari*.

The genus has not yet been recorded as boring in molluscan shells, but there is a variety of *A. Millari* commonly found in those of *Lima excavata*, Fabr., from Christiania and the Scandinavian coast. I have not yet observed it in any other shell, even in collections from the same locality.

Though not specifically distinct from the original type, this form seems worthy of attention on account of certain peculiarities in its mode of growth, and because it presents a striking instance of the inclusion of foreign spicules.

The Habit of the Sponge.—Scattered over the outer surface of the shell are circular openings, irregularly distributed and variable in size, leading into passages communicating with the chambers excavated by the sponge. The larger are about $\frac{1}{20}$ inch in diameter, and the passages into which they open are lined by a thin white crust. In many cases the opening is roofed over by a convex white disk with a central perforation, and similar structures are seen occasionally crossing the passages below the surface. (Pl. XIII. figs. 3, 4.)

On examination, these disks and the crust lining the passages are seen to consist entirely of the flesh-spicules.

In the region of the umbo the shell-substance has been eaten through in irregular patches, and the spaces are now filled by masses of spicules in which the flesh-spicules are far more numerous than the megascleres.

The question whether the sponge projected on the outside or grew over the surface in this region is of some interest, as in the original type there was distinct evidence of such an extension of growth outside the coral.

If there had been any such external growth, it is probable that remnants of it would be left, seeing that the more delicate papillæ over the small openings are still preserved. Moreover, the predominance of flesh-spicules in these patches suggests the

* Journal of the Royal Microscopical Society, vol. ii. 1879, p. 493, pls. xvii.-xvii. A.

presence of a dermal layer there. It seems probable therefore that the growth of the sponge is limited by the shell externally.

It is on examining the inner surface of the shell, however, that the special growth-characteristics of the sponge are seen. Instead of the smooth and even surface broken only by scattered perforations that is commonly seen in shells attacked by *Cliona* *, there appears in this case an irregular elevated area covered with blunt spines and papillæ.

Evidently the sponge has endeavoured to grow inwards, dissolving the nacreous layer and encroaching on the premises of the mollusc, instead of restricting its wanderings to the thickness of the shell. The mollusc has retaliated by depositing fresh shell-layers on the intruder, and the struggle has gone on till the chambers are several times the normal thickness of the shell, and are roofed over by a thin convex layer of secondary shell-substance, while the points at which branches have pushed further in are represented by thick conical papillæ.

The actively growing parts of the sponge are fine threads, sending off lateral branches or dividing dichotomously.

A careful examination of the extremities of the borings indicates that the excavation is carried on in the same manner as in the *Cliona* described by Nassonow †.

Immediately behind these growing tips the sponge thickens rapidly, but does not form distinct chambers, so that there is nothing of the moniliform appearance seen in some Clionas, while the older parts occupy wide confluent spaces only crossed here and there by pillars of shell.

The rapidity with which the shell is attacked is shown by the fact that only the extreme tips are in the normal thickness of the shell, while the convex secondary deposit is developed almost to the ends of the branches.

The best idea of the relations existing between the sponge and the shell is obtained from an examination of thin sections made through the chambers and papillæ.

* Ryder in the 'American Naturalist,' 1879, vol. xiii. p. 281, mentions the presence of papillæ on the inside of *Ostrea virginiana* peforated by a boring sponge, but does not specify the sponge. I have seen small papillæ due to the presence of *Cliona* in *Mytilus latus*; and Hancock mentions "clusters of pearl-like points" due to *Thoosa cactoides*, Ann. & Mag. Nat. Hist. (2) iii. 1849, p. 346.

† Zeitschrift für wiss. Zoologie, xxxix. pl. xviii. fig. 1.

Thus the section figured (Pl. XIII. fig. 6) shows that while the outer layer of the shell is left intact, the chamber occupied by the sponge is fully twice the normal shell-thickness. The nacreous layer is normally about ·75 millim. thick; over the chamber it is reduced to ·40 millim., except where the sponge has sent out two branches that have been covered by many concentric deposits to a thickness of 1–2 millim.

In the axis of each papilla thus formed lie spicules of the sponge, a pair of the large skeleton-spicules in one case lying close together parallel to the direction of growth and surrounded by the small flesh-spicules. The appearance of these sharp and spinose bodies lying in a crypt scarcely larger than themselves, like a *Pholas* in its burrow, might have been used as evidence in favour of the view that the excavating power of boring-sponges is due to the spicules.

One feature of considerable interest remains to be noted. It is only in quite the youngest regions that the sponge has been able to establish communication with the exterior on the inside of the shell. In all the older parts its attempt to grow inward, and the consequent deposit of shell over it, has prevented the formation of apertures. All the papillæ are closed at the apex, showing that the mollusc can deposit new shell faster than the sponge can dissolve it.

In the case of *Cliona*, there has been much difference of opinion as to the effect on one another of the two organisms. Thus while some writers have held that the sponge commonly dies first, Hancock's * opinion was that the death of the sponge came only on the breaking up of the shell, when, "Samson like, it perishes amidst the ruin produced by its own energy."

Whatever be the case with *Cliona*, it is evident that the sponge has not the best of the struggle in the present case, and it seems probable that the species is in a transition condition, and represents one of the stages in the evolution of shell-boring Porifera.

The original type inhabited a coral, in which it could grow freely in all directions. In the present instance a similar irregular growth has been most injurious if not fatal to the sponge, owing to waste of energy in dissolving shell that can be readily replaced, and to the deficient circulation resulting from the closure of apertures.

* Hancock, Ann. & Mag. Nat. Hist. iii. 1849, p. 323.

It is obvious that any individuals which tended to grow in two directions only would stand a very much better chance of survival, and that the continued selection of such individuals would result in highly specialized shell-boring sponges like *Cliona Fryeri* (Hancock), which burrows through *Placuna* shells of extreme thickness, establishing communications for each chamber on both sides, without setting up any irritation of the mollusc and consequent deformation of the shell.

The Spicules.—The *Skeleton-Spicules* or *Megasclera* are diactinal and pointed at the end (*oxeas*). They measure $\frac{1}{50}$ inch in length, and in breadth $\frac{1}{900}$ inch *, and the surface is covered with sharp conical spines; they are therefore somewhat smaller than those of *A. Millari*, Carter, and are rather more strongly spined.

The *Flesh-Spicules* or *Microsclera* are diactinal, consisting of a slightly bent shaft, blunt at the ends, bearing two whorls of papillæ, each situated at about one third of the length of the axis from the end †.

There are two forms of these microsclera:—(*a*) Larger ones in which the average length of the axis is $\frac{1}{500}$ inch and the papillæ are sessile. (*b*) Smaller forms only $\frac{1}{1000}$ of an inch in length, with the whorls of rounded knobs carried out from the axis on short stalks, and having consequently greater proportional width. These two types are well defined and do not graduate into one another. Both were present in *A. Millari*, but apparently only the smaller in the form first noticed as "*Gummina Wallichii*." Fragments of a homogeneous membrane which resist the action of acid are full of the small microscleres, and probably are remains of a dermal layer.

There is a third kind of spicule present in the form of slender *raphides*. These were also present in *A. Millari*, and commonly occur in groups of two or three lying at definite angles to one another, connected by dried sarcode in which the smaller microscleres also occur in bands forming a sort of network. Possibly these bodies are gemmæ.

The most important difference then between this variety and

* The dimensions are given in inches to compare with the original type.

† The flesh-spicules of the original specimen were blunt-ended though represented as acute. Mr. Carter asks me to state that though his initials were appended to the plate accompanying the description (Journal Royal Micr. Soc. 1879, pl. xvii.), this was a mistake, and he is only responsible for pl. xvii. A.

the typical *A. Millari* lies in the absence of the smooth microxeas (subskeleton spicules, Carter) so abundant in that specimen.

Through the kindness of Prof. Martin Duncan, F.R.S., I have been able to examine preparations of the original specimen, and the perfect series of gradations from the smooth acerate microxea to the "sceptrella" type is very striking. The simple forms pass into those with scattered papillæ, and these again into the typical microsclere with its two whorls. It may be noticed also that these "subskeleton-spicules" are more markedly diactinal than the skeleton-spicules; they are bent at varying angles, and, as Prof. Duncan pointed out to me, in some cases a well-marked projection at the angle looks like a rudimentary third ray.

Inclusion of Foreign Spicules.—The incorporation of a heterogeneous aggregate of spicules, sand-grains, foraminifera, &c. in the fibrous network of the skeleton is a familiar feature in certain sponges. Equally well known is the chance occurrence of a foreign spicule embedded in the soft tissues. The phenomenon of the presence of a number of similar spicules of one kind in the tissues of a sponge which has no general habit of accumulating foreign bodies is of a different nature, and important on account of the errors it might in particular cases occasion.

In 1880 Mr. S. O. Ridley* brought before the notice of the Society two cases of monaxonid sponges which had included spicules belonging to other genera; but, so far as I know, similar instances have not been recorded in the boring-sponges, which are indeed the last group in which such an occurrence would be expected.

Among the spicules first examined from the cavities excavated in the shell, there occurred a considerable number of rounded triangular disks, evidently derived from the dermal layer of some species of *Discodermia*. The explanation at first seemed to be that they had been accidentally washed into the cavities after the death of the sponge; but the absence of other foreign bodies, and the fact that they occur in different parts embedded in the dried sarcode together with the proper spicules, rendered that explanation untenable. Moreover, I have since found them in another specimen from Christiania, and, more important still, a group of the same spicules occurs in a preparation of the original specimen of *Alectona Millari*, kindly lent me by Dr. Hinde.

* Journ. Linn. Soc., Zool. vol. xv. 1880, p. 149.

Bearing in mind the difference in habit between the latter and the shell-boring form, the difference in the localities, and the freedom of both from foreign bodies generally, this association of such widely different spicules seems especially difficult to understand. Thinking that the determination of the species of *Discodermia* from which the spicules are derived and a comparison of its habit and distribution might lead to some explanation, I have endeavoured to find a record of such a form.

The spicules are perfectly constant in form and size; in shape triangular, with rounded angles and measuring ·15 millim. in diameter. The three canals in the disk are well-marked, and the rudimentary ray short, conical, and pointed. Over the surface are scattered circular papillæ.

The margin is always entire, never lobed—a character of the *young* dermal spicules in many Lithistids, but not a constant one in any known species.

The nearest form seems to be the *Discodermia papillata*, recorded by Mr. Carter from the Gulf of Manaar *. In this case the papillæ are very much smaller and more numerous, while all except the youngest dermal spicules are lobed.

As the species was encrusting and perhaps partly excavating a *Melobesia*, the description suggested the possibility of the presence of an excavating *Discodermia* in the shell of *Lima*, subsequently replaced by *Alectona*. If such were the case, however, the skeleton-spicules of the Lithistid would be found as well. The fact that only dermal spicules occur, indicates that they have been derived from some distance, as they are not only easily detached, but also easily conveyed by currents.

Systematic Position of the genus Alectona.—In conclusion, it may be as well to point out that no satisfactory position in classification has been found for the genus *Alectona*, and that the nature of its spicules prevents its inclusion in any of the groups of the Monaxonida as defined in recent systems.

Mr. Carter placed it with other boring sponges in his division "*Eccœlonida*"†, but there is no doubt that a classification founded on a single character must give way to one with a morphological basis.

In Dr. Vosmaer's arrangement ‡ the genus is placed after *Cliona*, but it is only added in the appendix.

* Ann. & Mag. Nat. Hist. (5) vol. vi. 1880, p. 146. † *Ibid.* p 58.

‡ Bronn, Klassen u. Ordnungen des Thierreichs—Porifera, p. 406.

Messrs. Ridley and Dendy *, and Dr. R. von Lendenfeld †, have classified the Monaxonida according to their spicular characters, but neither arrangement includes the genus under consideration. In their division of the 'Clavulina' are included forms with microsclera of the "stellate" type ‡ and with monactinal megasclera.

If, as the authors of the 'Challenger' Report on the Monaxonida are of opinion, the microsclera are of more classificatory value than the megasclera, it may be possible to place *Alectona* among the *Spirastrellidæ* near to *Latrunculia*, in spite of its diactinal spicules. Two species with oxeate skeleton-spicules have indeed been included in the latter genus by Mr. Carter §, and Messrs. Ridley and Dendy have described as *Latrunculia* (?) *acerata* a third species with similar megasclera associated with microsclera of the "sceptrella" form.

If such a form as this can be retained among the *Clavulina*, the genus *Alectona* may be placed also in that division; but it will possibly be found advisable to establish a new group for the reception of those Monaxonids that have oxeate megasclera and stellate diactinal microsclera. Moreover, if, as the spiculation of the original specimen of *A. Millari* seems to indicate, the sceptrella can be derived from a simple oxea by development of lateral scattered projections and their gradual localization round two centres, the classificatory value of stellate microscleres may have to be reconsidered.

EXPLANATION OF PLATE XIII.

Fig. 1. View of the inside of the shell of *Lima excavata*, Fabr., attacked by *Alectona Millari*. Nat. size.

Fig. 2. Outside of the same shell. Nat. size.

Figs. 3, 4. Ends of two passages opening on the surface of the shell. × 16.

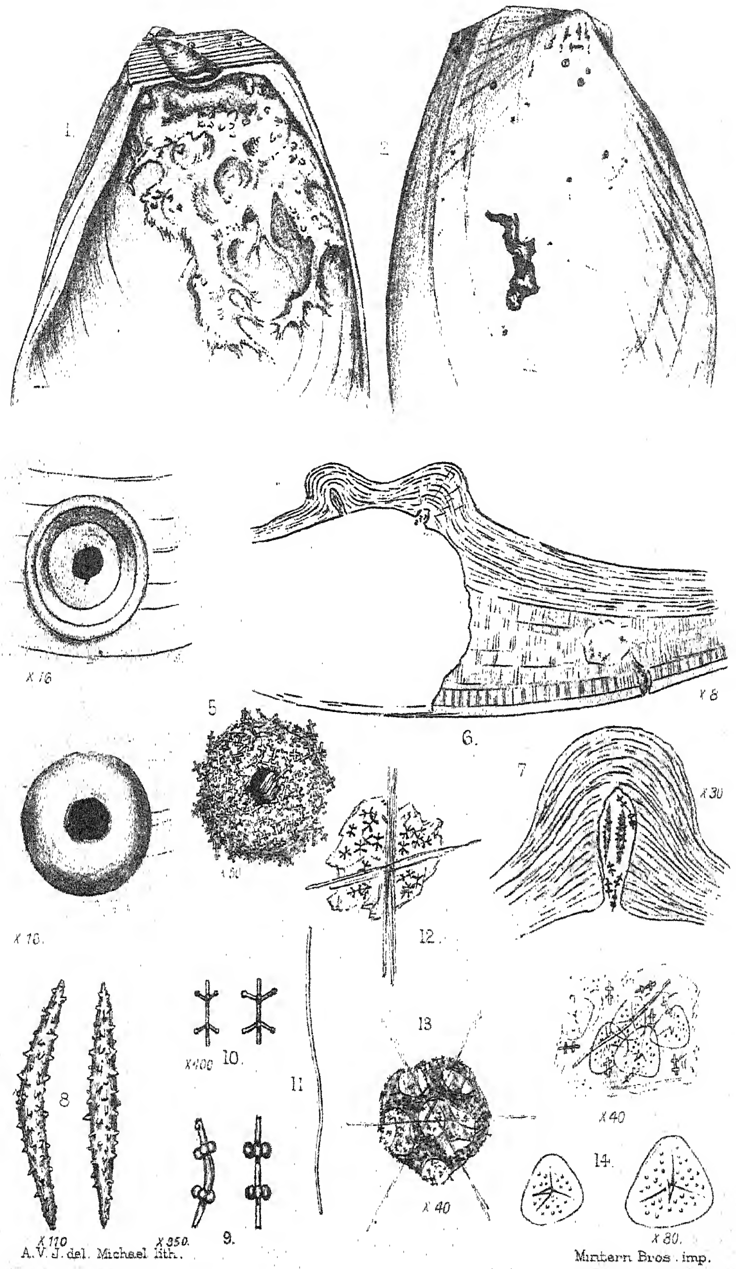
Fig. 5. Part of the spicular crust round the opening of one of the same. ×50.

* 'Challenger' Reports, vol. xx. pp. liii–lxviii.

† Proc. Zool. Soc. 1887, pp. 558–662.

‡ For spicules of the shape of the microscleres of *Alectona*, Mr. Carter proposed the name of "*sceptrellæ*." Messrs. Ridley and Dendy propose the term "*discastra*" as a synonym ('Challenger' Reports, Zool. vol. xx. p. 263), but the forms to which they apply it are monactinal. It would perhaps be useful to keep Mr. Carter's term for diactinal forms, and use *discastra* for monactinal spicules like those of *Latrunculia*.

§ Ann. & Mag. Nat. Hist. vol. iii. 1879, p. 298; vol. vii. 1881, p. 380.



A.V.J. del. Michael lith.

Mintern Bros. imp.

ALECTONA IN LIMA EXCAVATA

Fig. 6. Vertical section of the shell, passing through the chamber excavated by the sponge, and two of the nacreous papillæ. ×8.
Fig. 7. One of the same papillæ, ×30, showing spicules of the sponge in the centre.
Fig. 8. The skeleton-spicules. ×110.
Fig. 9. The larger flesh-spicules. ×350.
Fig. 10. The smaller flesh-spicules. ×400.
Fig. 11. One of the raphides.
Fig. 12. Part of dermal membrane?
Fig. 13. Gemmule? ×40.
Figs. 14, 15. Dermal spicules of a species of *Discodermia*, included in the tissues of the sponge. ×80.

On some Hermaphrodite Genitalia of the Codfish (*Gadus morrhua*), with Remarks upon the Morphology and Phylogeny of the Vertebrate Reproductive System. By G. B. Howes, F.L.S., F.Z.S., Assist. Professor of Zoology, Royal College of Science, London.

[Read 5th February, 1891.]

(Plate XIV.)

I. Codfish possessed of hermaphrodite genital glands have been known since the days of Leewenhoek (1688), Baster (1761), Yarrell (1845), Smith (1870), Max Weber (1884), and others have since recorded examples. The fullest description of such yet published is that of Max Weber alluded to *, to be referred to later, and his excellent paper embodies a *résumé* of all that was known up to the time of writing, with full references to the works of authorities cited. I have lately received from one of my past pupils (Mr. Walter C. Chappel, of Sunderland) the genitalia figured on Plate XIV., and our President has afforded me opportunity of examining five specimens in the Museum of the Royal College of Surgeons, under his charge. My best thanks are due to these gentlemen for their kindness and liberality.

II. I give below the total lengths of the ovaries of the

* Nederl. Tijdschr. v. d. Dierkunde, Jhg. v. Af. 2, p. 21 (1884).

specimens examined by Prof. Max Weber and myself. In no case was either the length or condition of the fish whence the organs were obtained known; but, except for a fatty degeneration undergone by the testis in the example numbered III., the animals appear to have been, in every case, healthy and productive of normal sexual elements.

Table of Measurements of observed cases, with remarks thereon.

The roman numerals refer to the Catalogue of the Royal College of Surgeons Museum.

	Total length in Centimetres. Left ovary.	Total length in Centimetres. Right ovary.
I. Max Weber, *loc. cit.* p. 23.	17·5	16·5
	Testis present at posterior end of each ovary; confluence established on each side, by means of a short duct entering posterior pointed extremity of ovary.	
II. Chappel (Pl. XIV. figs. 1, 2).	12	16
	Testis present on right side only; confluence as with I.	
III. 454 C	17	13
	Testis (in bulk as large as the two ovaries together) on left side only; confluence over a wide area of the ventral postero-external border. Substance of testis largely fatty and degenerate; spermatozoa looked for but not observed.	
IV. 446	19	20·5
	Testis on middle left side; confluence established over a wide area of postero-external border. Motile spermatozoa abundant.	
V. 447	12	12
	Testis on right side; confluence as for I., II., by well-defined duct.	
VI. 448	12	12
	Testis on right side; confluence established by a short duct, at anterior extremity of ovary.	
VII. 449	10·5.	10·0
	Testis on right side; confluence established with anterior extremity of ovary as for VI.	

In all six specimens which I have examined, both ovary and testis bore the normal characters and appearance; and in Mr. Chappel's example, which reached me fresh and unpreserved, the colour and general relationships of the organs were in every respect normal, and identical with those described by Max Weber (*l. c.* p. 24). Indeed, except for an important difference in the contents of the two (*cf. infra*, p. 542), and for the presence of a remnant of the genital duct, his detailed description might serve for the right half of my own specimen. The general characters of the several specimens enumerated differ most conspicuously in respect to the degree of backward prolongation of the ovaries beyond their point of union. In this, however, as in the inequality in length of the ovaries of opposite sides, there is nothing which changes consequent upon extrusion of the ova, together with the ordinary limits of individual variation, will not explain. And, moreover, the facts above tabulated clearly indicate that, in the Cod, the differentiation of a testis on the one or other side does not lead up to a corresponding reduction of the ovary. Rather the contrary (*cf.* fig. 1).

The genital organs of the Codfish are so well known, and Max Weber's description cited is so complete, that it is only necessary here to dwell upon certain special details of the specimens alluded to above. Firstly, as to the duct connecting the ovary and testis. Max Weber alludes to it (*l. c.* p. 24) as the "vas deferens—really a tube," &c.; he figures (pl. iii. fig. 2) a style passed into it, but tells us nothing of its orifice of communication with the ovary. In his drawing it is represented as skirting the inner two-thirds of the attached border of the testis; in my specimen (*d.t.*, fig. 1) it was much shorter, and the testicular substance was set upon it in the manner of a rosette. On laying open the duct I found it to be a spacious tube (*d.t.*, fig. 2), honeycombed in the manner of that of the normal male, over its upper and inner areas. Its lower moiety was longitudinally subdivided by a kind of septum (v'.), which shut off a small orifice placing it postero-externally in communication with the interior of the ovary. There arose from the postero-internal wall of the ovarian capsule a stout membranous fold (v''.), which projected inwards and passed, for a distance of 1 centim., towards the orifice of communication with the testis-duct; on nearing that it expanded to form a well-marked valve-like structure. It would thus appear that not only was there present a duct competent to

transport spermatozoa, but that a complicated apparatus existed in connexion with the same.

Spermatozoa were found in the testes of similar specimens examined by Weber and Halbertsma (*cf.* Weber, *l. c.* pp. 26, 27). Dr. Weber says of his specimen that (p. 24) the contents were of the nature of sperm mother-cells and spermatozoa "still united into bundles with their heads and tails in apposition," and that neither the male nor the female elements were as yet ripe. Mr. Chappel's specimen reached me, as already stated, while quite fresh. The remains of its duct of communication with the exterior (*d.g'*, fig. 1) were found to contain mobile spermatozoa; and, on careful examination, I was able not only to obtain these from the so-called vas deferens, but from the interior of the ovary also. Max Weber and others have surmised that the spermatozoa must, in such cases, ripen and pass out through the ovary; and my own observation proves this to have been realized. No one has yet detected the passage of ripe ova to the exterior in an hermaphrodite Codfish; and, in strictness, the declaration of a complete and functional hermaphroditism for this animal cannot be valid until such passage shall have been observed. In view, however, of the condition of the ovaries, and of the near approach towards maturation of their contents in my own specimen and in those of previous observers, there can be no reasonable doubt that we have to deal with true hermaphrodites, capable of producing both ova and spermatozoa.

Hermaphroditism among Teleostean fishes is well known. Aristotle knew *Serranus* to be hermaphrodite; and the recent researches of Syrski and Brock* and others† have placed it beyond doubt that the hermaphrodite species of that fish are regularly self-fertilizing. Among the Teleostei generally the hermaphroditic condition is known for 16 genera and 19 species at fewest. In three of the former (*Centrolophus*, *Ophidium*, *Smaris*) the conditions remain doubtful, aggregations of ova having been found in the testes. The hermaphroditic condition has been recorded among the *Clupeidæ*, *Cyprinoidei*, *Esocidæ*, *Gadoidei*, *Labroidei*, *Percoidei*, *Pleuronectidæ*, *Scomberoidei*, *Squamipinnes*, and *Sparoidei*—that is to say, among typical and wide-spread families of four of the six great orders now custom-

* Morphol. Jahrb. Bd. iv. 1878, pp. 567 *et seq.*

† *Cf.* Brock, and Max Weber, *loc. cit.*

arily conceded, one or two others remaining doubtful *. An hermaphroditic condition of the genital glands has been claimed for isolated members of other classes of Vertebrates. It is well known to occasionally manifest itself in the Amniota †; it is stated to be the constant condition for a solitary Batrachian; Pallas and Benecke have recorded it for *Acipenser* ‡, and Semper for the Selachii §. Again, Langerhans has detected the tails of spermatozoa among young ovarian ova of *Amphioxus* ‖; and Cunningham ¶ and Nansen ** have described what must be admitted to be, at least, a modified form of hermaphroditism in the Myxinoids.

Collation of the literature of this subject brings into prominence two striking facts, viz.:—α. That the frequency of occurrence of hermaphrodite genital glands in the Teleostei is common and widespread, as compared with other orders and suborders of Vertebrata; β. that whereas in the last-named (setting aside the Marsipobranchii, in which the conditions are somewhat special, and the Bidder's organ of the Anura, as to the real nature of which we are still in doubt ††) the dominant condition is that of replacement of one of the two testes in an ovary, or *vice versâ*, in the Teleostei it is that of the differentiation of the same gland into organically continuous ovary and testis. Notwithstanding the considerable attention which this subject has received, these facts have never before been sufficiently emphasized; and it remains now to follow them to their logical issue, and to enquire whether they may not have a deep significance. What, briefly, is the meaning of the repeated reversion of the genital gland to an organically continuous hermaphroditic type, which well nigh characterizes the Teleostei among Vertebrates?

Max Weber has proposed to distinguish between what he terms "true hermaphroditism" (such, for example, as that exemplified in the Codfish figured by him, in which testis and

* For detailed list see Max Weber, *loc. cit.* pp. 36, 37.

† *Cf.* Sir James Simpson's article "Hermaphroditism," in Todd's 'Encyclopd. of Anat. and Phys.' vol. ii. p. 684.

‡ *Cf.* Max Weber, *loc. cit.* pp. 37–40.

§ *Cf.* Van Wijhe, Archiv f. mikr. Anat. Bd. xxxiii. p. 504 (1889).

‖ Ibid. Bd. xii. 1876, p. 326.

¶ Journ. Micr. Sci. n. s. vol. xxvii. p. 49 (1887).

** Aarsber. Bergens Mus. 1887, op. vii.

†† *Cf.* Knappe, Morph. Jahrb. Bd. i. p. 489 (1886).

ovary are continuous on either side and debouch on to the exterior), and those cases in which (*loc. cit.* p. 29), where the sexes are ordinarily distinct, individuals occasionally present themselves with testis and ovary on opposite sides. He would regard the latter as "pathological"; Brock has, however, objected to this distinction *, upon what appear to me good grounds. It would be surely preferable to retain the term "pathological" for exclusively morbid and diseased conditions; and the well-established fact that the same blastema gives rise, by diverse modification, to both ova and spermatozoa, justifies us in regarding the various conditions of the adults last alluded to as degrees of abnormality † and nothing else.

The belief that the ancestors of the Chordata were hermaphrodite, for which Hæckel and others have specially contended, is daily gaining ground ‡. So frequent is the occurrence, and so marked are the physiological variations of the hermaphroditic condition of the genital glands among Teleostean fishes, that Syrski and Brock have been enabled to classify the same in accordance as the species are invariably § or only occasionally hermaphrodite, or as they are (*Serranus*) or are not (*Chrysophrys*) self-fertilizing. Leewenhoek, in 1688, adduced good reason to suppose that in the hermaphrodite Codfish which he examined the genital products ripened alternately, and that the animal functioned first as a male. In the specimen which I here figure this—the characteristic feature of "successive hermaphroditism"—had been realized (*cf. ante*, p. 542). Brock has shown that in *Chrysophrys auratus* the male and female genital products ripen alternately. Cunningham, in 1887, recorded (*loc. cit.*) the presence of both ova and spermatoblasts in the genital glands of the young Hag (*Myxine glutinosa*); and Nansen (*loc. cit.*), working at the same facts at the same time, has shown this animal to be in reality a protandric hermaphrodite, producing mature spermatozoa during its earlier existence, mature ova later in life. Apart from the fact that this Myxinoid, lowest of the low among living Vertebrata, has been thus shown to be regularly

* Zeitschr. f. wiss. Zool. Bd. xliv. p. 373 (1886). *Cf.* Max Weber, Tijdschr. d. Ned. Dierkund. Vereen. ser. ii. D. i. p. 128 (1885–87).

† And that only as compared with the now predominant unisexual type.

‡ *Cf.* Van Wijhe, *loc. cit.* p. 504.

§ *Serranus cabrilla, hepatus, scriba*; *Chrysophrys auratus, Pagellus mormyrus* (?). For detailed list see Max Weber, Tijdschr. *cit.* 1884, pp. 36–37.

hermaphrodite, the facts above cited are sufficient to suggest that the hermaphroditic condition, so marked among the Teleostei, may be reversional to, if not realistic of, that which must have been the ancestral condition for the Chordata *. And if, as seems to me most reasonable, the unicyclic maturation of the ovotestis of the Hag is an abbreviated and specialized equivalent of the multicyclic one of the hermaphrodite Teleosteans, the question arises whether, in view of this, the bony fishes may not have retained a more primitive condition of the genital glands than have the other Gnathostomata †. On this supposition, their frequent reversion to the condition of hermaphroditism becomes at once intelligible, and, indeed, is that which might be expected.

Brock has shown ‡ that the reproductive apparatus of the Stylommatophorous Pulmonata is laid down upon the female plan, and that the later differentiation of the male parts is sometimes never effected. He seeks to apply this principle to the hermaphrodite Teleostei (*loc. cit.* p. 374); but, from examination of such of the latter as I have been able to obtain, I am strongly of opinion that further investigation will prove him to have been mistaken.

* Laulanié has attempted to distinguish between successive phases of sexual neutrality, hermaphroditism, and unisexuality, in the ontogenetic development of the genital glands of the Amniota. He institutes comparisons with what he believes to have been the phylogenetic evolution of the organs named, and builds up an argument for primitive hermaphroditism (Comp. Rend. t. ci. pp. 393–395, 1885, & Bull. Soc. Toulouse, t. xx. pp. 13–16). Unfortunately, his observations are insufficient and of too incomplete a nature to justify the full acceptance of his statements.

† Experimental researches of the last six years have considerably modified the old belief that access to the sea is indispensable for the maturation of the genital glands of the Salmones. Not only have fish been found in the Parr stage with functional testes, but Day and Maitland have succeeded in rearing young from the eggs of 32 months' land-locked Parr of *Salmo salar* (Trans. Linn. Soc. Lond., Zool. ser. 2, vol. ii. 1885, p. 447 [*cf.* also Day's 'British and Irish Salmonidæ,' pp. 101 *et seqq.*]). In view of the above considerations, the probability that the earlier maturation of the genital gland of the male Salmonoid may be the expression of an ingrained tendency towards regular hermaphroditism must not be overlooked; and I would suggest the same interpretation of the recent discovery by Holt, that in the Mackerel the male organ would appear to be the first to mature (Trans. R. Dublin Soc. vol. iv. ser. 2, p. 437, 1891).

‡ Zeitschr. f. wiss. Zool. Bd. xliv. p. 374 (1886).

It is interesting, in view of this and in its possible bearing upon the ancestry of the Chordata, to recall the fact * that the *Tunicata*, unlike the higher hermaphroditic Chordata, are mostly protogynous.

III. That the genital ducts of adult Teleosteans, when present, are invariably continuous either with the membranes which suspend the genital glands or (most modified term) with those which invest them, is well known. They are frequently paired, becoming median and unpaired only when the glands are, as in the female Cod, united and saccular. The steps in the realization of this continuity have been worked out by Jungersen † and others. The urino-genital organs of the Teleostei differ collectively from those of all other Vertebrates, with the exception of the *Ganoidei* and *Marsipobranchii*, in the absence of undoubted vestiges of the genital ducts of the opposite sex.

Balfour, in dealing, at the end of his career, with the development of the urino-genital system of the Vertebrata generally, laid it down as his final conclusion ‡ that the ducts of the Teleostei are most probably "in both sexes . . . modified Müllerian ducts" (*cf. l. c.* p. 606); and he further pointed out that while analogy would suggest that they might (p. 580) "correspond with the Müllerian ducts of Elasmobranchii," &c., on this point there was "no positive embryological evidence." Balfour was contending for his belief in the homology of the "Müllerian ducts" throughout the Vertebrata, as tubes formed in relation to the head kidney and to a splitting of the segmental ducts §. The tendency of post-Balfourian investigation into the morphology of the vertebrate urino-genital system has been towards the overthrow of this conception; and, indeed, with the recent discoveries of Van Wijhe ||, Marshall and Bles ¶, and others named on the next page, the Elasmobranchii occupy a well nigh isolated position as the only great group of Vertebrata for which it has not been either

* *Cf.* Herdman in 'Challenger' Reports, vol. xiv. Tunicata, p. 23.

† *Loc. cit.* p. 179.

‡ Comp. Embryology, vol. ii. p. 605.

§ *Cf.* Sedgwick, Quart. Journ. Micr. Sci. n. s. vol. xxi. p. 468 (1881).

|| Archiv f. mikr. Anat. Bd. xxxiii. p. 461 (1889).

¶ Studies Biol. Lab. Owens Coll. Manchester, vol. ii. p. 185 (1890).

overthrown or, at least, challenged on tolerable grounds. Balfour and Sedgwick were the first to clearly show that the Müllerian duct of the Amniota might be (chick) a compound structure, for the first part of its course split off as a solid and backwardly-extending rod "from the outer or ventral wall of the Wolffian duct." Concerning the "posterior part of its course," Balfour wrote that "its growing point lies in a bay formed by the outer walls of the Wolffian duct, but does not become definitely attached to that duct. It seems, however, possible that, although not actually split off from the walls of the Wolffian duct, it may grow backwards from cells derived from that" (*loc. cit.* p. 592) *.

Conspicuous among the post-Balfourian researches afore alluded to are those of Milhálkovics †, Jungersen ‡, Wiedersheim §, and others, which have revealed the fact that the Müllerian duct of the Amniota is formed, mainly if not entirely, as a derivative of the peritoneum, wholly independent of the Wolffian duct, arising far forwards and gradually extending back. Jungersen's extensive inquiry was especially directed towards the Teleostei. He found that the genital duct of the female arises as a peritoneal derivative, formed late—that is, subsequently to the differentiation of the genital gland, with the investment of which it becomes subsequently connected ‖. Relying upon his discovery of this independent origin he argues, from analogy to the independent origin of the Müllerian ducts of the Amphibia and Amniota, in favour of an homology between the two, and shows ¶ that the genital duct of the female Teleostean may be looked upon as either partially or entirely homologous with the Müllerian duct proper, in accordance with different views which he formulates.

Jungersen has observed that whereas in the females the genital duct arises independently of the gland, in the males the two appear to be from the first continuous; and he urges this as a fundamental distinction between the sexes. The leading variations in the structure and relationships of the fully

* *Cf.* also Quart. Journ. Micr. Sci. vol. xiv. n. s. p. 9 (1879).

† Month. Internat. Journ. of Anat. & Hist. vol. ii. p. 284 (1885).

‡ Arbeit. a. d. Zool. Zoot. Instit. Würzburg, Bd. ix. p. 89 (1889).

§ Archiv f. mikr. Anat. Bd. xxxvi. p. 410 (1890).

‖ *Loc. cit.* pp. 179 *et seqq.*

¶ *Loc. cit.* pp. 192–200.

formed ducts of the males and of those females in which they are completely closed are well known to affect the opposite sexes indifferently; these weighty facts of anatomy bear out Balfour's deduction (*cf. infra*) that the ducts are homologous in both sexes, and completely override the force of Jungersen's discovery. By a Müllerian duct we understand one invariably arising far forwards, either in relation or immediate proximity to the head kidney, when such exists, and becoming for the most part completed by a process of backward extension. The researches of Jungersen show clearly that the one distinguishing feature of the Teleostean genital ducts is their restriction, alike in origin and relationship, to the posterior genital region; and, whatever may be said for their supposed homology in the two sexes, this fact is, to my mind, fatal to the supposition that that of the females represents a Müllerian duct as ordinarily understood.

Jungersen's Teleostean's genital duct arises, like Balfour and Sedgwick's posterior segment of the Chick's Müllerian duct, late, and in juxtaposition to the base of the Wolffian or segmental duct. The Müllerian duct of the *Anura* is asserted by Hoffmann* to arise for the most part as a backwardly extending derivative of the peritoneal epithelium. Fürbringer describes the Müllerian duct of the Urodela† as formed (*Salamandra*) of an anterior segment derivative of a thickened and backwardly extending portion of the peritoneal epithelium, and a posterior one arising as a solid product of the wall of the pro-renal duct‡. These facts not only strengthen the conclusion that the female genital duct of the Amniota and Amphibia is in all probability a compound structure, but, in view of the isolated position of the Elasmobranchii already referred to on p. 546, they suggest that it may not be serially homologous for the three groups. Upon this possibility future investigation must decide. The facts, taken in conjunction with those to which I have herein drawn attention, point, I believe, most markedly, to another and simpler conclusion, viz.: that the genital ducts of the Teleostei are in both sexes distinct from those of Elasmobranchs, Amphibians, and Amniota, and that

* Zeitschr. f. wiss. Zool. Bd. xliv. p. 594 (1886) (*cf.* Marshall & Bles, *op. cit.* pp. 142–143).

† Morph. Jahrb. Bd. iv. p. 31 (1878).

‡ *Cf.* v. Wijhe & Jungersen, *op. cit.*

they are (as has been already suggested for that of the females by McLeod *, Brock †, and Max Weber ‡) independent structures *sui generis*. At the same time I consider it not improbable, from the facts afore cited, that the posterior moiety of the Müllerian duct of at least the Amphibia and Amniota may be the vestige of that which has survived in the Teleostei, and that its anterior moiety is a more recent structure which has replaced the latter in time.

Brock inclines to the belief that the hermaphroditic condition of the genital glands has been independently evolved within the vertebrate phylum. I venture to think that had the discoveries of Cunningham and Nansen (*ante*, p. 543) preceded Brock's, he would have arrived at a different conclusion. These and the constantly hermaphroditic habit of the Tunicata appear to me irreconcilable with his supposition, to say nothing of the facts which I have emphasized in dealing with the Teleostei (*ante*, p. 545) and of Langerhans' discovery of spermatozoa in the ovary of *Amphioxus*. While I entirely disagree with Brock's second proposition, I fully acquiesce in his first, and with Beard § regard both Teleostei and Ganoids as at all stages wholly destitute of Müllerian ducts. The genital duct of these fishes is, like the gland which it serves, hermaphroditic in tendency; and, in view of the facts and considerations with which I have dealt, I consider that their reproductive system may, most satisfactorily and with some foundation, be regarded as the most generally primitive among living Gnathostomata.

IV. Huxley, in 1883, drew attention ‖ to the lack of appreciation which has attended Rathke's observations on the genital ducts of fishes; and he proceeded to describe the parts now in question in the female Smelt (*Osmerus eperlanus*), showing them to be readily harmonizable with those of the other Salmonoidei and Ganoids, *Lepidosteus* excepted. The Smelt's ovary is, as

* Arch. d. Biol. vol. ii. p. 497 (1881).
† Zeitschr. wiss. Zool. Bd. xliv. p. 375 (1886).
‡ Morph. Jahrb. Bd. xii. p. 396 (1887).
§ Anat. Anz. 1890, p. 158.
‖ Proc. Zool. Soc. Lond. 1883, p. 132.

Huxley shows, lamelligerous and freely pendent, and reflected ventro-externally; while its duct is incompletely tubular and directly continuous with the mesovarium. The ducts of opposite sides pass back, converging as they do so, to communicate with the exterior through the mediation of a shallow sac opening by a porus genitalis disposed immediately behind the anus. Huxley has pointed out, among other things, that this pore can have nothing to do with the pori abdominales of Ganoids and Elasmobranchs; and, were not his reasoning sufficient, the later discovery by Max Weber * of the general co-existence of the two in Salmonoids disposes of future misunderstanding on this point.

Balfour and Parker have shown (as Huxley points out †) that the oviduct of *Lepidosteus* passes through an Osmeroid stage in its development; and the recent researches of Jungersen have proved ‡, on appeal to embryology, that the oviduct of *Osmerus* is, as Huxley supposed, homologous with that of all other bony fishes and Ganoids.

It is now known that whereas in the majority of Teleostei and in *Lepidosteus* the ovary is a closed sac, lodging a central cavity continuous with the lumen of its duct, in the *Osmeroidei* and in the remaining Ganoids the former is a folded plate and the latter a more or less incomplete tube with a wide ostium; while in the *Salmones*, *Murænidæ*, and *Cobitis* §, as in the *Galaxiidæ*, *Notopteridæ*, and *Hyodon* ||, the "oviduct" is either insignificant or absent.

Jungersen's researches place it beyond doubt that the genital pores of those Teleostei devoid of genital ducts are one and the same with the ostia of the latter when present. Relying upon his discovery that the genital glands are well differentiated before traces of their ducts ever appear, he has concluded (*loc. cit.* p. 183) that the ductless condition must have been the more primitive one. Against this must be set:—i., the invariable

* Morph. Jahrb. Bd. xii. p. 366 (1887).

† *Loc. cit.* p. 136.

‡ *Loc. cit.* pp. 181 & 192.

§ Rathke, "Ueb. d. Darmkanal u. d. Zeugungsorgane d. Fische," Schrift. d. naturf. Gesellsch. z. Danzig, H. iii. Bd. 24 (1824).

|| *Cf.* Günther, 'Introd. to Study of Fishes,' p. 158; and Jungersen, *loc. cit.* pp. 1 & 182-3.

presence of the ducts in the male Teleostean; ii., the undoubted fact that the general organization of *Osmerus* is of a much lower type than that of either *Salmo* or *Cobitis*, not to say than that of the other ductless genera named.

On the whole, I am inclined to acquiesce in the view of Rathke *, Huxley †, and Balfour ‡, and to regard the Salmonoid-Murænoid type as the expression of a loss of the ducts; but I look upon the Osmeroid type as the lowest term in the series, and consider the more typically Teleostean condition (ex. *Gadus*) on the one hand and the Salmonoid-Murænoid one on the other, as having resulted from divergent modification of the former along opposite lines. Huxley has proposed § to term the closed condition (ex. *Gadus*) the *Cystoarian*, and that of the Smelt the *Elasmoarian*, and for the ductless type the designation *Gymnoarian* may perhaps suffice. I would point out, in support of my conclusion, that *Argentina*, whose genital glands have been shown by Max Weber ‖ to be in a less specialized condition than those of *Osmerus*, has well-developed ducts; and that the researches of McLeod, Balfour and Parker, and Brock have shown the cystoarian type to pass through an elasmoarian stage. Further, by way of guarding against future confusion between the simple so-called "oviduct" of the Teleostei and Ganoids and the more complex Müllerian oviduct of other Vertebrata, which are in all probability non-homologous, the former might be termed the *ovary-duct*.

V. To turn, in conclusion, to the *Marsipobranchii*. The genital organs of these fishes discharge their products through a couple of perforations in the side walls of the so-called urinary or urino-genital cloaca. Müller long ago described in relation to these so-called "abdominal pores" membranous tubes; and Vogt and Pappenheim have described in relation to each a short

* *Loc. cit.* pp. 124–125.

† Proc. Zool. Soc. Lond. 1883, p. 137.

‡ Comp. Emb. vol. ii. p. 580.

§ Lectures, 1884. For permission to embody the terms employed in this paragraph, the author acknowledges his deep indebtedness to his honoured master.

‖ Morph. Jahrb. Bd. xii. p. 395.

canal. Unfortunately, subsequent investigation has not borne out these statements *.

The urinary and genital pores of the Teleostei open upon the exterior, as is well known, either independently or through the mediation of a common urino-genital sinus, and the two orifices may, in some of the first-named cases, be embraced by a tegumental fold suggestive of a vestige of the sinus named. In view of the researches, more especially of Huxley, Balfour, and Jungersen, already recapitulated, it can hardly be doubted that the genitalia of the Ganoids and Teleostei conform to a common type, variable in nothing more than degree of inter-communication between the genital and urinary ducts. That the cystoarian condition, as exemplified by *Lepidosteus* on the one hand and the majority of living Teleostei on the other, would appear to have resulted from a parallelism of modification is, I think, sufficiently clear.

I have shown reason (*ante*, p. 548) for adhering to Balfour's belief that the generative ducts are homologous in both sexes of Teleostei; and if it be true of them it must be so of the Ganoidei also. If this is, as I believe, sound, it is fair to assume, in consideration of the facts of anatomy and development recapitulated in the foregoing pages, that there must have existed a piscine type in which the male apparatus was in the elasmoarian condition—in which, that is to say, the so-called "vas deferens" was an incomplete tube with a wide ostium. No ichthyotomist will need to be reminded that this is precisely the condition of the parts in the Sturiones, except that no one has yet succeeded in proving that the duct transmits the spermatozoa †. In the Sturiones the genital glands extend throughout the whole length of the post-pericardiac cœlom; and Max Weber's discoveries among the Salmonoids ‡ show that in the higher Osteichthyes we have to deal with an abbreviation of this condition. In fact, the Sturgeons present us with exactly that which my hypothesis demands. Balfour and Parker have concluded § that "the most primitive

* *Cf.* Ewart, Journ. Anat. & Phys. vol. x. p. 488 (1876).

† *Cf.* Hyrtl, Denkschr. Akad. Wien, 1855, pp. 1–5; Johannes Müller (Hyrtl *cit.*), and Jungersen, *loc. cit.* pp. 185–187.

‡ And especially *Argentina*, see Morph. Jahrb. Bd. xii. p. 395.

§ Phil. Trans. 1882, part ii. p. 423.

type of Ganoid genital ducts is found in the Chondrostei." In consideration of the facts alluded to on p. 551, I would go further and suggest that the general plan of structure of the Chondrostean's genitalia is the most primitive of that of all living Gnathostomata, and that it most nearly realizes that type from which the latter originally diverged.

The Salmones are among those Teleostei in which the ovary-ducts are absent, and the urino-genital sinus in them (Pl. XIV. figs. 3 & 4, *s.*) assumes the form of a well-defined sac which receives the ureters posteriorly (*bl.*") and is in the female perforated laterally by the pori genitales (cf. *br.*" of fig. 3). Comparison of the male (fig. 4) shows these pores to correspond in position with the ostia of the genital ducts (*d.g.*"). These facts have been long ago described and figured by Carus and Otto *. Comparison of those Salmonoids possessed of both abdominal pores and oviducal slits (figured by Carus and Otto and by Max Weber) with the Marsipobranchs, seems to me little short of fatal to the view entertained by Balfour †, Bridge ‡, and others, that the pori genitales of the latter represent the pori abdominales of Elasmobranchs, Ganoids, and Teleosteans. If they do, in entering into relationship with the walls of the urinary sinus they must have undergone a translocation for which there is no suggestion of a parallel elsewhere. On the other hand, comparison of both sexes of the Marsipobranchs with those of the Salmones points, much more naturally, towards a direct homology between the parts in question. Deepen the sac of the female Salmon (fig. 3), even to the extent of that of the male (fig. 4), or shorten that of the Marsipobranch, and it would be difficult to distinguish between the two types. And if, as Scott asserts §,

* Erläuterungstafeln z. vergleichend. Anat., Heft. v. Leipzig, 1840, pp. 8-9, pl. iv. fig. 5 & pl. v. fig. 3.

† Journ. Anat. & Phys. vol. x. pp. 34-35 (1876).

‡ *Ibid.* vol. xiv. p. 86 (1879).

§ Morph. Jahrb. Bd. vii. p. 167 (1882). *Cf.* Shipley, Quart. Journ. Micr. Sci. n. s. vol. xxvii. p. 352 (1887). Compare also the account of the development of the urinary ducts of the Teleostei, given by McIntosh and Prince, Trans. R. Soc. Edinb. vol. xxv. part iii. p. 785 (1890). Most interesting and suggestive in view of Scott's declaration is the recent discovery by Liszt (Zeitschr. wiss. Zool. Bd. xlv. p. 595, and Anat. Anz. 1890, p. 640) that in *Crenilabrus pavo* the so-called urinary bladder of the embryo opens for a short time into the base of the alimentary canal.

the urino-genital sinus of the Marsipobranch is a hypoblastic sac, split off from the enteric tube, the difficulty of homologizing the perforations of its side walls with the cloacal pits of the other Pisces, which are epiblastic in origin, will be still further increased. With this the mind reverts to Rathke's original view *, shared by Gegenbaur and others, that the Marsipobranchii should be included in the category of those fishes which have lost their genital ducts.

Inasmuch as their ducts are absent in both sexes, they may be said to be in a *gymnogonarial* condition, as distinguished from the gymnoarian Osteichthyes, in which the females only are ductless.

The chief obstacle in the way of accepting Rathke's view has undoubtedly been the failure of embryologists to find traces either of a splitting of the segmental duct or of parorchis and parovarium in the young of these fishes. If the view of the phylogeny of the Teleostean "ovary-duct" which I have sought to establish should remain valid, this objection will have been largely dispensed with; for, inasmuch as the Marsipobranchs, together with the *Salmones*, *Murænidæ*, *Galaxiidæ*, *Notopteridæ*, *Hyodon*, and *Cobitis*, would appear to have lost not the Müllerian duct but the primitive and hermaphroditic "ovary-duct," the demand for vestiges of the former will be no longer a *sine quâ non*.

Balfour has long ago pointed out † that "the condition of the urino-genital organs in Selachians is by no means the most primitive found amongst Vertebrates." Powerful arguments in favour of a belief in convergence of the living Marsipobranchii, Ganoidei, and Teleostei towards a common stock, unrepresented at the present day, have been lately put forward ‡ by Beard. Edinger has shown the structure of the prosencephalon of the Batoidei to be more primitive than that of the Sharks, and I have been enabled to prove § that, with respect to its dorsal mesentery, the Torpedo *Hypnos subnigrum* is far more primitive than all other Plagiostomes. The latest palæontological researches of Cope ‖ and

* *Loc. cit.* p. 123.

† Journ. Anat. & Phys. vol. x. p. 28 (1876).

‡ Anat. Anz. 1890, pp. 146 & 179.

§ Proc. Zool. Soc. Lond. 1890, p. 671.

‖ Amer. Nat. vol. xxiv. p. 402 (1890).

Smith Woodward * have forced them to conclude that both the living Elasmobranchs and Teleosteans are specialized members of their types; they look upon the two as equally ancient, and as connected with some lower types of greater antiquity, now wholly extinct. Putting all together, I accept their conclusions, except so far as they involve the so-called archipterygial type of fin; and that the facts and considerations dealt with in this paper tend in the same direction will, I trust, be obvious from the context.

VI. *Lepidosteus* is well known to be the only living cystoarian Ganoid. Balfour and Parker, when dealing with its reproductive organs, observed that its ovary and ovary-duct pass through an Osmeroid stage (*cf. ante*, p. 550). On having concluded † that the genital products of the male are transported by vasa efferentia through the mesonephros, they suggested that "the Teleostei must . . . . have sprung from Ganoids in which the vasa efferentia had become aborted." Jungersen has shown reason for doubting this observation (made only upon one specimen of 60 centim. in length) ‡; but even if it should hold good, I am of opinion that their suggestion by no means follows as a logical conclusion. For equally good arguments might be brought forward to show that *Lepidosteus*, instead of representing, as they would have us believe, a type transitional in these respects between Elasmobranchs and other Ganoids, might typify a culminating term in the Ganoid series as now represented; the "vasa efferentia," as it were, first appearing instead of languishing. The position of Balfour and Parker assumes that the type of structure exemplified in the urino-genital system of the living Elasmobranchs is necessarily more primitive than that of the Ganoids and Teleosteans. All subsequently discovered facts of comparative embryology of the system named are in complete opposition to this; and it will, I trust, be admitted that the general structural features of *Lepidosteus* are most nearly in harmony with

* British Mus. Cat. Fossil Fishes, vol. ii. pp. xi, xxi (1891).

† Phil. Trans. 1882, part ii. p. 424.

‡ *Loc. cit.* p. 188.

the views herein put forward (*cf.* p. 552). Indeed, the study of *Lepidosteus*, and of the facts just briefly alluded to, suggests—if it be granted that the Chordata were primitively hermaphrodite,—that the differentiation of the Wolffian and Müllerian ducts was associated with the first step towards unisexuality, and that the presence of remains of the one or other of these ducts in the opposite sexes of the Vertebrata in the form of a non-functional vestige is far from being an index of hermaphroditism, as has been frequently supposed.

My friend Prof. W. N. Parker has lately shown * that in *Protopterus* Müllerian ducts are present in both sexes. He has further made the very important discovery † that in the male vasa efferentia are absent, the testis-duct being, like that of Osteichthyes, continuous with its gland—or, to state the facts otherwise, that epididymis and vas deferens are unrepresented. From my standpoint two most striking conclusions arise from this, viz.:—(α) that in the perfection of unisexuality the formation of the Müllerian duct must have preceded that of the vas deferens; and (β) that the Dipnoi must have struck off from the parent stock during the interval in the differentiation of the two ‡.

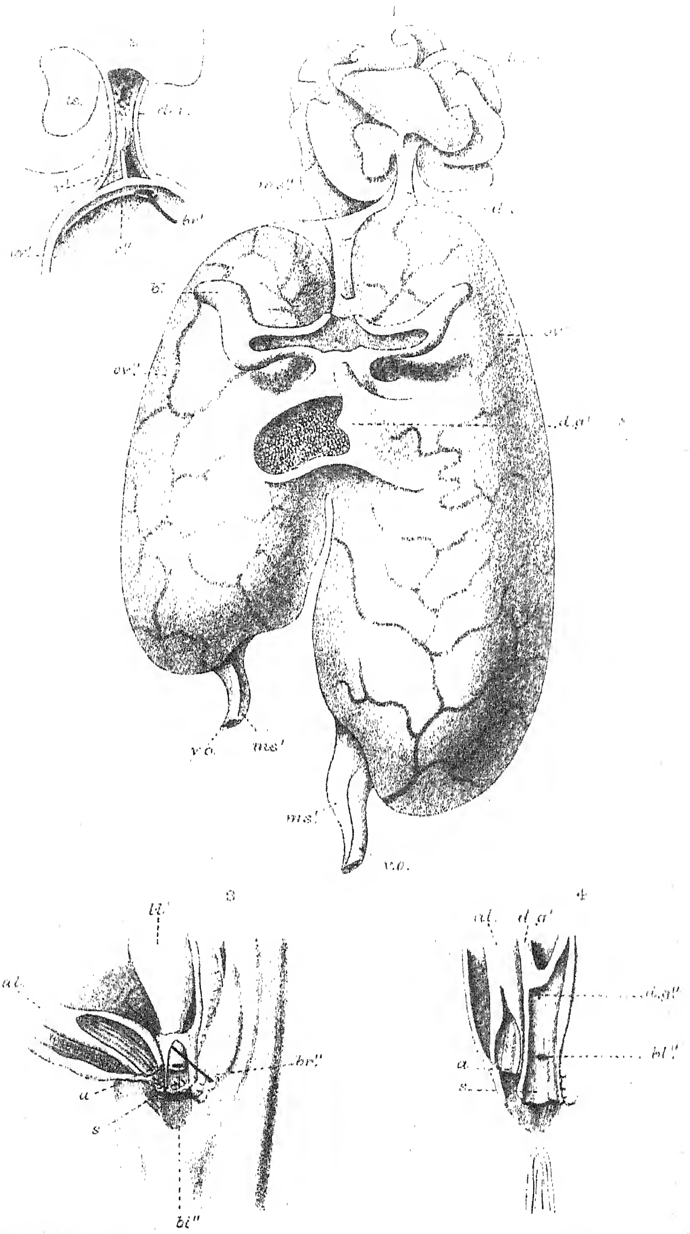
The living Vertebrata, as classified by their urino-genital system, fall into two readily discernible series, viz.:—(α) the *Nephrorchidic series*, embracing the Elasmobranchii, Amphibia, and Amniota, in which vasa efferentia are present and the excretory organ is an accessory to reproduction in the male; (β) the *Euthorchidic* § *series*, embracing the Ganoids, Teleostei, Marsipobranchii, and Dipnoi, in which vasa efferentia are unrepresented, and the Wolffian or segmental duct is exclusively renal in function. That the latter type must be looked upon as the more primitive is clear, from all recent discovery in the morphology of the

* Berichte d. naturf. Gesellsch. Freiburg i. B., Bd. iv. Heft 3, p. 22 (1888).

† As yet unpublished. I here acknowledge my indebtedness to him for permission to mention his observation.

‡ It follows from this that whatever be the affinities of the Dipnoi, they can have nothing to do with living Ganoids. Indeed they appear to me to have left the Holocephalic branch of the Elasmobranch stock prior to the differentiation of the immediate ancestors of its living members. In this belief and in my views of the inter-relationships of the Ichthyopsida, I find myself in complete harmony with Beard (*cf.* Anat. Anz. 1890, p. 186).

§ εὐθὺς, straight.



G.B.H. del.ad nat.
M P Parker lith.

West, Newman imp.

GENITALIA OF HERMAPHRODITE CODFISH.

urino-genital system. The Dipnoi appear to occupy a partially central position in the collective series; and while the Marsipobranchii are undoubtedly referable to a much lower stock than all other living Chordata with the exception of *Amphioxus* and the Tunicata, their living representatives would appear to have suffered the loss of their genital ducts. The facts concerning them, as I have endeavoured to interpret them, point to an apterygial* Chondrichthyan with hermaphrodite duct bearing genitalia as, to my mind, the most logically conceivable ancestor of the living Vertebrata.

I claim for my hypothesis,—i., a not inconsiderable foundation in fact; ii., that it enables us to harmonize the facts of morphology of the genitalia of Vertebrates (and especially those of the *Osteichthyes* so long considered anomalous), at least as satisfactorily as any other yet postulated. It renders explicable the absence of vestiges of the ducts of the opposite sexes in the *Osteichthyes* and *Myxichthyes*, in that they would appear to have never been formed; and it furnishes at least a possible explanation of the constantly recurring reversion of the Teleostean genital glands to an hermaphroditic type.

EXPLANATION OF PLATE XIV.

Fig. 1. Genital glands of an hermaphrodite Codfish (*Gadus morrhua*); with remains of genital duct, urocyst, and suspensory ligaments. Ventral aspect. One half natural size.

Fig. 2. The same; head of right ovary with testis-duct, laid open to show their interior and details of communication. Natural size.

Fig. 3. *Salmo salar*, ♀ Dissection to show the interior of the urino-genital sinus, and relations, to the same, of the urinary and genital orifices. After Carus and Otto (ref. see p. 553).

Fig. 4. *Salmo salar*, ♂. Comparison dissection to fig. 3. After Carus and Otto.

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* I would suggest this term to express the absence of paired fins, as distinguished from the apodal condition in which the pelvic members are alone wanting.

Reference letters.

a. Anus.
al. Intestine.
bl'. Urocyst (so-called urinary bladder).
bl''. Orifice of the same.
br'. Bristle passed from interior of right ovary into testis-duct.
br''. Bristle passed into porus genitalis of right side.
d.g'. Genital duct.
d.g''. Orifice of the same.
d.t. Testis-duct.
m.s'. Suspensory ligament of ovary.
m.s''. Mesenteric fold.
ov'. Right ovary.
ov''. Left ovary.
ts. Testis.
s. Urino-genital sinus.
v'. Longitudinal septum of testis-duct.
v''. Valve-like fold at base of testis-duct.
v.o. Ovarian vein.

A Revised Classification of the TUNICATA, with Definitions of the Orders, Suborders, Families, Subfamilies, and Genera, and Analytical Keys to the Species. By W. A. HERDMAN, D.Sc., F.L.S., Professor of Natural History in University College, Liverpool.

[Read 5th February, 1891.]

DURING the three years which have elapsed since the last part of the report upon the Tunicata collected during the 'Challenger' Expedition was written, I have had opportunities of examining, more or less in detail, many large collections of Tunicata from various parts of the world, including especially three important series of specimens from Australian seas which are now in my laboratory, viz.:—the collection of the Australian Museum, Sydney (from which I am drawing up a Museum Catalogue); a collection made by Mr. Bracebridge Wilson in the neighbourhood of Port Phillip, and sent to me for description by Prof. Baldwin Spencer; and, lastly, the collection made by Prof. Haddon in the Torres Straits. I have also been able to make a number of observations from the living animals on various parts of our own and the French coasts. Consequently I feel that I am in a position now to revise the classification put forward in the 'Challenger' Report, to deal with those few genera not included in that work and those described since 1888, and to

differentiate, so far as can be done in tabular form *, under each genus the numerous species not represented in the 'Challenger' Collection.

There has never been any sufficiently comprehensive work on the Tunicata describing all the known species, and although this present classification and series of tables cannot pretend to be such a revision, still it may be useful as a preliminary essay in that direction, clearing the ground and marshalling the species in groups. I can scarcely hope that my system of classification will commend itself at all points to my fellow-workers: in the primary divisions and subdivisions, however, I have made practically no change upon the 'Challenger' system, which has been adopted by most writers on the Tunicata since. Still less can I hope to have escaped error in the enumeration and arrangement of the numerous species. The literature of the Tunicata is so scattered, and many of the descriptions so meagre or even misleading, that it is very difficult in the first place to collect the literary material, and in the second place to arrange it correctly. The first to attempt this work in a group is pretty sure to commit sins both of omission and of commission, but may reasonably hope for lenient treatment from his critics. I shall be very glad to receive and acknowledge corrections and additions to the lists.

I desire to acknowledge with cordial thanks the very efficient assistance I have received from two advanced students of University College, Liverpool, Miss A. E. Warham, B.Sc., and Miss J. H. Willmer, who, while working in my laboratory during the past year, have prepared for me microscope specimens and drawings of a very large number of Ascidians. Miss Warham especially has devoted a great deal of time to sectionizing numerous colonies of Compound Ascidians; and both ladies have undertaken a part of the laborious work of looking-up references, of collecting together the various species of the genera and of comparing the characteristics given by different authors, and so have enabled me to complete the tables much sooner than with my very limited leisure would otherwise have been possible.

Although a linear classification, such as this of necessity is,

* Occasionally the characters made use of in some of the tables are not quite satisfactory. It is not possible in all cases to distinguish allied species by one or two characteristics briefly put. They will serve, however, to indicate which original descriptions should be consulted.

cannot express adequately the relations existing between the various groups, still I believe that these groups are all natural assemblages, with the exception of the "Ascidiæ Compositæ," which is to be regarded as being polyphyletic in origin, having been derived from several distinct groups of simple Ascidians which have independently acquired the property of budding so as to form colonies. I believe, then, that although it is a matter of convenience to retain still the suborder Ascidiæ Compositæ, it may some day become necessary to break up this artificial assemblage of colonial forms, and to place the sections beside their nearest allies amongst the Ascidiæ Simplices.

I have purposely abstained from being too critical in regard to closely related or poorly defined genera and species, believing it to be more useful in this preliminary revision of the group to admit all such doubtful forms if they have any characteristic by which they can be distinguished. A number of the older species of the Tunicata require to be examined afresh (those it is possible to obtain) and re-described, as the original descriptions are no longer sufficient to characterize them properly and to distinguish them from the numerous species which have been described (more fully) since. I have thought it better to err on the side of admitting into the tables some of these imperfectly characterized species rather than to run the risk of doing an injustice to former authors by suppressing species which may eventually turn out to be distinct and entitled to recognition. Others of the older species which in the present state of our knowledge cannot be placed in the tables, but which I do not *know* to be mere synonyms, have been referred to in footnotes or put in separate lists under the genera to which they probably belong.

I have inserted the authorities and the dates of formation of the various groups, but have not considered it necessary to encumber the text with references to the original papers. There can be no difficulty from the author's name and the date in finding the work in question in any bibliography of the Tunicata, such as that given in the 'Challenger' Reports *. I have

* It is unnecessary to acknowledge in detail the full use I have made of the published works of my predecessors and fellow-workers at the Tunicata, as I have ransacked every paper known to me for lists, characters, and other hints as to the affinities of those species I have not been able to examine myself. I have found specially useful the recent papers of Traustedt, Sluiter, von Drasche, and Lahille.

also, after the authorities for the species, given in brackets a brief indication of the geographical distribution of each species, and have there made use of the following contractions:— N. Atl. (North Atlantic); S. Atl. (South Atlantic); N.W. Eur. (the north-western coasts of Europe, such as British area, Danish seas, &c.); E. N. Am. (the eastern coast of North America); Arct. (the Arctic seas); W. Ind. (the West Indies); Med. (the Mediterranean, including the Adriatic); Red S. (the Red Sea); Ind. O. (the Indian Ocean); Mal. (the seas of the Malay Archipelago); Austr. (the coasts of Australia); A. Arct. (the Antarctic); Mag. (Straits of Magellan and the neighbourhood); S. Pac. (South Pacific); N. Pac. (North Pacific Ocean); and Jap. (Japanese Coast).

TUNICATA, *Lamk.*, 1816.

This class is divided into three Orders, the Ascidiacea, the Thaliacea, and the Larvacea.

Order I. ASCIDIACEA, *Blv.*, 1827.

This group includes fixed or free-swimming Simple or Compound Ascidians, which in the adult are never provided with a tail and have no trace of a notochord. The free-swimming forms are colonies, and the simple Ascidians are never free-swimming.

The test is permanent and well developed; as a rule it increases with the age of the individual.

The musculature of the mantle is in the form of an irregular network, there being no regular circular bands.

The branchial sac is large and well developed. Its walls are perforated by numerous slits (the stigmata) opening into a single peribranchial cavity, which communicates with the exterior by the atrial aperture.

The anus opens into the peribranchial cavity.

Many of the forms reproduce by gemmation, and in most of them the sexually produced embryo develops into a tailed larva.

The Order Ascidiacea is divided into three Sections—the Ascidiæ Simplices, the Ascidiæ Compositæ, and the Ascidiæ Luciæ.

Suborder I. *ASCIDIÆ SIMPLICES*, Savigny, 1816.

This group contains fixed (rarely unattached, but never free-swimming) Ascidians which are solitary, and very rarely reproduce by gemmation; if colonies are formed, the members of the colony are not buried in a common investing mass, but each has a distinct test of its own.

The Ascidiæ Simplices include four families—the Molgulidæ, the Cynthiidæ, the Ascidiidæ, and the Clavelinidæ.

Family I. MOLGULIDÆ, *Lac.-Duth.*, 1877.

Body usually free, sometimes fixed, rarely pedunculated.

Test cartilaginous, coriaceous, or membranous, usually covered with sand &c., which adheres to long hair-like processes of the test. Branchial aperture 6-lobed, atrial aperture 4-lobed.

Branchial sac usually longitudinally folded (5 to 7 folds on each side); internal longitudinal bars not papillated; stigmata more or less curved, usually arranged in spirals.

Tentacles always compound, usually much branched.

Intestine attached to the inner surface of the mantle on the left side.

Renal sac present, upon the right side of the body.

Gonads on the inner surface of the mantle, usually developed on both sides. Larvæ usually tailed, in a few species anurous.

This is the most highly differentiated family of the Ascidiæ Simplices. It contains the following genera:—

	Branchial sac with no folds..	1
	Branchial sac with from 5 to 7 longitudinal folds on each side.........	2
1	A pair of gonads, one on each side, the left one anterior to the intestine...	**Paramolgula.**
	A single gonad, alongside intestine..	3
3	Infundibula large, conical, placed in longitudinal rows, one in each mesh	**Eugyra.**
	Infundibula relatively small, corkscrew-like, many in each mesh.	**Bostrichobranchus.**

2 { Body attached, pedunculated, free from sand, and with stigmata not in spirals .... **Ascopera.**
  { Generally free, globular, and sandy, with stigmata in spirals 4

4 { With 5 folds on each side of the branchial sac..................... **Pera.**
  { With 6 or 7 folds on each side 5

5 { With the branchial and atrial lobes laciniated .... **Ctenicella.**
  { With no such laciniation 6

6 { With a single gonad, on the left side..................... **Eugyriopsis.**
  { With 2 gonads, one on each side .... **Molgula.**

PARAMOLGULA, *Traustedt*, 1885.

Body free.

Test covered with adhering sand.

Branchial sac with no folds. Stigmata spirally coiled and arranged in infundibula.

Gonads present on both sides of the body.

This genus contains the single species

Paramolgula Schulzii, Traustedt. (Mag.)

EUGYRA, *Alder & Hancock*, 1870.

Body globular, unattached. Branchial aperture 6-lobed, atrial 4-lobed.

Test usually thin and transparent, incrusted with sand or plain.

Branchial sac with no folds. Internal longitudinal bars few, broad, and ribbon-like. Infundibula large, conical, formed of regularly coiled vessels, which form a double spiral meeting at the apex. They are placed in longitudinal rows, one in each mesh.

Tentacles compound.

Gonad forming a single mass situated on the left side close to the intestine.

The species of this genus may be distinguished as follows :—

{ Body attached by a very long peduncle. *E. pedunculata*, Traust. (Arct.)
{ Body not pedunculated 1

1 { Test thin, transparent, without sand. *E. kerguelenensis*, Herdm. (A. Arct.)
  { Test opaque, covered with sand 2

2	Siphons concealed by a fold of anterior end of test. *E. bilabiata*, Sluit. (Mal.)	
	Siphons not concealed by a fold	3
3	Both siphons very long, as long as diameter of body. *E. pilularis*, Verr. (E. N. Am.)	
	Siphons not very long	4
4	Gonad confined to intestinal loop, 60 tentacles. *E. adriatica*, v. Dr. (Med.)	
	Gonad not confined to intestinal loop	5
5	Gonads paired* ... *E. symetrica*, v. Dr. (Arct. & Med.)	
	Gonad single, crossing over intestinal loop	6
6	With a circular area on side free from sand. *E. glutinans*, Möll. (Atl.) (= *E. arenosa*, Ald. & Hanc.).	
	Body entirely covered with sand. *E. globosa*, Hanc. (N.W. Eur.)	

BOSTRICHOBRANCHUS, *Traustedt*, 1882.

Body free, sometimes sandy.

Test moderately thick and tough, wrinkled.

Branchial sac with no folds. Infundibula of small size, corkscrew-like, and placed many in a mesh.

Gonad present on the left side only.

This genus contains a single species, *Bostrichobranchus manhattensis*, Dekay, from the east coast of North America.

ASCOPERA, *Herdman*, 1880.

Body more or less pyriform, pedunculated, attached.

Test thin, between membranous and leathery in texture, having no adhering sand and no hair-like processes.

Branchial sac with seven folds on each side. Stigmata straight or curved, but not arranged in spirals. No infundibula.

Tentacles compound.

Alimentary canal on left side, running antero-posteriorly.

Gonads developed on both sides. The gland on the left side lies ventral to the rectum.

There are two species, separated thus:—

* This species seems to belong to *Paramolgula* rather than to *Eugyra*?

	Body pyriform, stalk short, stigmata mostly curved. *A. gigantea*, Herdm. (Kerguelen Isl.)	
	Body club-shaped, stalk long, stigmata mostly straight. *A. pedunculata*, Herdm. (Kerguelen Isl.)	

PERA, *Stimpson*, 1852.

Body attached or free, may be slightly stalked.

Test sandy or not.

Branchial sac with five folds on each side. Stigmata in spirals or in rows.

This genus (which is simply those Molgulids with five folds only on each side of the branchial sac) contains four species*:—

	Test delicate and transparent ...... *P. chrystallina*, Möll. (N. Atl.)	
	Test opaque and more or less sandy	1
1	With very long branchial and atrial siphons. *P. longicollis*, Wagner. (Arct.)	
	With the siphons short or inconspicuous	2
2	Stigmata of branchial sac curved... *P. Hancocki*, Herdm. (N.W. Eur.)	
	Stigmata straight .... *P. Carpenteri*, Herdm. (N. Atl.)	

CTENICELLA †, *Lacaze-Duthiers*, 1877.

Body fixed.

Test covered with sand. Branchial and atrial lobes laciniated or cleft at their edges into numerous sharp processes. Atrial siphon furnished with a bilobed valve.

Branchial sac with seven folds on each side. Stigmata spirally coiled, arranged in infundibula.

Dorsal lamina with the margin toothed.

Gonads present on both sides of the body.

The four species of *Ctenicella* may be distinguished thus:—

Dorsal tubercle horseshoe-shaped .... *C. Lanceplaini*, Lac.-Duth. (N.W. Eur.)	
Dorsal tubercle S-shaped	1

* *Pera Huxleyi*, Macd., is a *Rhodosoma* (see Ascidiidæ).

† *Molgula complanata*, Ald. & Hanc. (N.W. Eur.) may belong to this genus. If so, it differs from the other species of *Ctenicella* in having only 6 folds on the left side (right, of Hancock) of the branchial sac. *Lithonephrya eugyranda* of Giard probably belongs to *Ctenicella*.

1	Dorsal tubercle with long axis parallel to long axis of body	2
	Dorsal tubercle with long axis transverse to long axis of body. *C. Morgatæ*, Lac.-Duth. (Med.)	
2	Tentacles slightly branched, dorsal lamina strongly toothed. *C. appendiculata*, Heller. (Med.)	
	Tentacles well branched, dorsal lamina slightly toothed. *C. Korotneffi*, Lac.-Duth. (N.W. Eur. & Med.)	

MOLGULA*, *Forbes*, 1853.

Body usually globular, attached or free, often encrusted with sand and mud. Branchial aperture 6-lobed, atrial 4-lobed; lobes not laciniated.

Test usually thin, but tough; often with hair-like processes on the outer surface.

Mantle thin and membranous; musculature usually feeble, consisting chiefly of long radiating bundles arising from the bases of the siphons, and of short fusiform clumps of fibres scattered through the mantle.

Branchial sac with 6 or 7 longitudinal folds on each side. Stigmata more or less curved, coiled spirally in infundibula.

Tentacles compound.

Alimentary canal on the left side of the branchial sac.

Gonads developed on both sides.

Renal organ in the form of a crescentic sac placed in the centre of the right side of the mantle, and usually containing concretions.

The numerous species † of *Molgula* which have been sufficiently characterized may be separated as follows:—

	With 6 folds on each side of the branchial sac	1
	With 7 folds	2
1	Lower ends of the folds provided with tongue-like processes. *M. euprocta*, v. Dr. (Med.)	
	No such processes present	3

* Includes *Gymnocystis*, Giard, and *Anurella*, Lac.-Duth.

† *Molgula psammodes* was described by Traustedt in 1880, but was not included in the table of species of the genus given by the same author in 1882, and consequently has probably been given up. According to Carus, it is the same as *M. occulta*, Kupff.

3 { Small papillæ on the edges of the stigmata. *M. impura*, Heller. (Med., N.W. Eur.)
  { No such papillæ 4

4 { Dorsal tubercle elongated, not horseshoe-shaped 5
  { Dorsal tubercle horseshoe-shaped 6

5 { Dorsal tubercle nearly linear, subarcuate. *M. eugyroides*, Traust. (S. Atl.)
  { Dorsal tubercle irregularly convoluted, serpentiform. *M. Holtiana*, Herdm. (N.W. Eur.)

6 { Aperture between horns of dorsal tubercle turned to the left.................... 7
  { Aperture turned posteriorly 8

7 { 4 to 6 inter. longit. bars on a fold; anus with plain free edge. *M. Koreni*, Traust. (W. Ind.)
  { 2 to 4 inter. longit. bars on a fold 9

9 { Anus with a fringed edge .... *M. simplex*, A. & H. (N.W. Eur.)
  { Margin of anus smooth .... *M. macrosiphonica*, Kupf. (N.W. Eur.)

8 { Edge of dorsal lamina entire 10
  { Edge of dorsal lamina toothed 11

10 { Anus with a plain edge .... *M. tenax*, Traust. (W. Ind.)
   { Anus with a fringed edge.................... 12

12 { 3 int. long. bars on a fold .... *M. ampulloides*, v. Ben. (N.W. Eur., Med.)
   { 4 int. long. bars on a fold .... *M. socialis*, Alder. (N.W. Eur.)

11 { Anus with plain edge .... *M. Lutkeniana*, Traust. (N.W. E.)
   { Anus with a fringed edge .... *M. tubifera*, Œrsted. (N.W. Eur.)

2 { Dorsal tubercle simple, circular, and funnel-shaped, no horns. *M. pyriformis*, Herdm. (S. Atl.)
  { Dorsal tubercle curved, with horns.................... 13

13 { Dorsal tubercle horseshoe-shaped 14
   { Dorsal tubercle S-shaped.................... 15

14 { Margin of dorsal lamina fringed or toothed 16
   { Margin of dorsal lamina plain 17

16 { Only the posterior half of body sandy. *M. gigantea*, Cunn. (Mag.)
   { The whole of body sandy .... *M. occulta*, Kupff. (N.W. E., Med.)

17 { Siphons retracted between folds of test; no sand between the apertures .... *M. oculata*, Forb. (N.W. Eur.)
   { No such folds of test present 18

18 { Papillæ on the margins of the stigmata. *M. occidentalis*, Traust. (W. Ind.)
   { No such papillæ present 19

19 { Horns of dorsal tubercle merely turned in 20
   { Horns of dorsal tubercle coiled spirally; aperture turned to right side 21

20 { Test not sandy 22
   { Test sandy 23

22 { Outside of siphons echinated, or having pointed projections 24
   { Siphons not echinated 25

24 { Only the branchial siphon echinated. *M. echinosiphonica*, Lac.-Duth. [(N.W. Eur.)
Both siphons echinated .... *M. nuda*, Wagn. (Arct.)

25 { Body globular, not attached .... *M. cæpiformis*, Herdm. (N.W. E.)
Body attached 26

26 { With a short peduncle .... *M. pedunculata*, Herdm. (A. Arct.)
With no peduncle... 27

27 { Attached by a wide area partly on left side. *M. citrina*, A. & H. (N.W. Eur.)
Attached by a narrow area at posterior end. *M. Helleri*, v. Dr. (Med.)

23 { Aperture of dorsal tubercle turned to right side; anus with entire free edge... 28
Aperture of dorsal tubercle turned posteriorly; anal margin entire, but adhering .... *M. septentrionalis*, Traust. (?Arct.)

28 { Six series of conical papillæ on the test round the branchial aperture. *M. nana*, Kupff. (N.W. Eur.)
No such papillæ present; siphons long. *M. solenota*, Lac.-Duth. (N.W. [Eur.)

21 { No sand &c. on the test .... *M. gregaria*, Less. (Mag.)
Test sandy 29

29 { Mantle thick and opaque, with muscles forming a close network. *M. horrida*, Herdm. (Mag.)
Mantle thin, transparent, with the usual Molgulid musculature 30

30 { Inferior margin of anus adhering 31
Margin of anus entire, free; large genital papillæ on each side of rectum .... *M. Bleizi*, Lac.-Duth. (N.W. Eur.)

31 { Stigmata small and short; anus bilabiate. *M. grœnlandica*, Traust. (N. Atl.)
Stigmata very long; anus rounded... *M. roscovita*, Lac.-Duth. (N.W. [Eur.)

15 { 4 int. long. bars on a fold .... *M. Forbesi*, Herdm. (Austr., Mal.)
5 or 6 int. long. bars on a fold ...... *M. Martensii*, Traust. (Ind. O.)

Molgula boreas, Traustedt (Arct. ?), appears to come in here beside *M. Forbesi* and *M. Martensii*, but I am unable to find a description which will give differentiating characters.

EUGYRIOPSIS, *Roule*, 1885.

Body ovoid, attached; not incrusted with sand.

Test smooth, thick, with no hair-like processes.

Mantle thin; musculature weak, but both longitudinal and transverse.

Branchial sac with 7 folds on each side. Stigmata curved, and coiled spirally in infundibula.

Tentacles compound.

Alimentary canal on the left side.

Gonad single, placed on the left side, anterior to the intestinal loop.

This genus contains the single species *Eugyriopsis Lacazei*, Roule, from the shores of Provence.

The following Molgulids cannot, on account of the very imperfect descriptions which have been given of them, be placed in any of the tables. Probably most of them belong to the genus *Molgula*; several may be synonyms, or young conditions of other species:—

M. tubulosa, Rathke. (N.W. Eur.)
M. inconspicua, Stimps. (Austr.) Only 4 branchial folds?
M. inconspicua, Ald. & Hanc. (N.W. Eur.) 6 branchial folds.
M. sordida, Stimps. (E. N. Am.)
M. producta, Stimps. (E. N. Am.)
M. arenosa, Stimps. (E. N. Am.)
M. pannosa, Verr. (E. N. Am.)
M. retortiformis, Verr. (E. N. Am.)
M. littoralis, Verr. (E. N. Am.)
M. papillosa, Verr. (E. N. Am.)
M. pilularis, Verr. (E. N. Am.)
M. pellucida, Verr. (E. N. Am.)
M. labeculifera, Stimps. (China.) [? Ascidiidæ.]
M. conchilega (?).
Cæsira parasitica, Macd. (Austr.)
C. ficus, Macd. (Austr.) 7 branchial folds.
C. pellucida, Macd. (Austr.)
M. siphonata, Ald. (N.W. Eur.)
M. adhærens, Giard. (N.W. Eur.)
Lithonephrya decipiens, Giard. (N.W. Eur.)
Gymnocystis comosa, Giard. (N.W. Eur.)
Eugyra arenata, Verr. (E. N. Am.)

Family II. CYNTHIIDÆ, *Lac.-Duth.*, 1877.

Body usually attached, rarely free, sometimes pedunculated.

Test membranous or coriaceous, rarely cartilaginous or covered with sand. Branchial aperture usually 4-lobed, atrial 4-lobed.

Branchial sac longitudinally folded; internal longitudinal bars not papillated. Stigmata straight, never forming spirals.

Tentacles simple or compound.

Intestine on the left side, only slightly, or not at all, attached to the mantle.

Gonads on the inner surface of the mantle, either on both sides or on one only.

This very large and important family contains three well-marked sections or subfamilies—the Bolteniinæ, the Cynthiinæ, and the Stylinæ.

Subfamily Bolteniinæ, *Herdman*, 1880.

Body attached and pedunculated; peduncle usually very long; branchial and atrial apertures having either 4 or less than 4 lobes.

Test coriaceous, membranous or cartilaginous, not covered with sand.

Branchial sac with more than four folds on each side.

Tentacles compound.

This subfamily includes four genera, which may be separated thus:—

	Fine longitudinal vessels and stigmata present	**Boltenia.**
	No fine longit. vessels in branchial sac	1
1	Branchial aperture 4-lobed	**Cystingia.**
	Branchial aperture more or less triangular	2
2	Stalk relatively short and thick	**Fungulus.**
	Stalk relatively long and slender	**Culeolus.**

Boltenia, *Savigny*, 1816.

Body more or less globular, fixed on a long peduncle; apertures lateral, 4-lobed.

Test coriaceous or cartilaginous.

Branchial sac longitudinally folded, with 6 or more folds on each side. Fine longitudinal vessels present, forming straight stigmata.

Tentacles compound.

Dorsal languets present.

The species of *Boltenia** may be distinguished as follows:—

	Peduncle not longer than body .... *B. legumen*, Lesson (Mag.)	
	Peduncle many times longer than body	1
1	Body globular or nearly ovate, regular	2
	Body irregular, flattened or lobed	3

* *Clavelinopsis rubra*, Fewkes, is probably a *Boltenia*, but the description insufficient.

2	Peduncle sublateral	*B. ovifera*, Linn. (N. Atl.)	
	Peduncle terminal and median		4
4	Body subreniform	*B. reniformis* *, MacL. (Arct.)	
	Body elongate-ovate		5
5	Branchial aperture on same level with peduncle; apertures sessile.	*B. elegans*, Herdm. (N. Atl.)	
	Branchial aperture not on same level with peduncle; apertures prominent	*B. fusiformis*, Sav. (Arct.)	
3	With large lobes or tubercles from the test		6
	With no such projections		7
6	No spicules in the branchial sac	*B. gibbosa*, Heller. (Austr.)	
	With spicules in the branchial sac	*B. tuberculata*, n. sp. (Austr.)	
7	Body much elongated, narrow fusiform.	*B. Bolteni*, Linn. (Arct.)	
	Body not so elongated	*B. pachydermatina*, Herdm. (S. Pac., Austr.)	

CYSTINGIA, *MacLeay*, 1824.

Body ovate, attached to a very short peduncle. Branchial aperture 4-lobed, atrial irregular, both sessile.

Test subcoriaceous.

Branchial sac with longitudinal folds (about fourteen). The transverse vessels and longitudinal bars form a loose meshwork not divided into true stigmata by fine longitudinal vessels.

Tentacles compound.

Alimentary canal on left side; stomach very long.

Gonads on both sides of body.

There is only one species known, *Cystingia Griffithsii*, MacLeay, brought from the Arctic Seas near Winter Island by Mr. W. N. Griffiths, who accompanied Captain Parry.

The following species, probably belonging to *Boltenia*, are insufficiently characterized and cannot be placed :—

Boltenia rubra, Stimpson. (E. N. Am.)
B. microcosmus, Ag. (E. N. Am.)
B. Burkhardti, Ag. (E. N. Am.)
B. ciliata, Möller. (Arct.)
B. australis, Q. & G. (Austr.)
B. spinifera, Q. & G. (Austr.)

FUNGULUS, *Herdman*, 1882.

Body globular, borne on a short thick peduncle attached to the anterior end. Branchial aperture triangular, atrial bilabiate.

Test cartilaginous, but very thin, not modified on the peduncle.

* *Ascidia clavata*, Fabr., may be this species.

Branchial sac with several slight folds on each side; meshes square, no stigmata. No spicules present in the walls of the vessels.

Dorsal lamina a plain membrane.

Tentacles compound.

Gonads a single gland on each side.

This genus contains the single species *Fungulus cinereus*, Herdm., dredged during the 'Challenger' Expedition in the Southern Ocean from a depth of 1600 fathoms.

Culeolus, *Herdman*, 1880.

Body fixed, pedunculated, more or less ovate; the anterior end, where the long peduncle is attached, is narrower than the posterior. Branchial aperture more or less triangular; atrial aperture bilabiate.

Test cartilaginous, often very thin, usually rough and papillated on the outer surface.

Mantle thin, musculature not greatly developed.

Branchial sac with about 6 longitudinal folds on each side; consisting of transverse vessels and internal longitudinal bars, forming a wide-meshed network. There are no stigmata, the fine longitudinal vessels being absent. The larger vessels, especially the internal longitudinal bars, are supported by a system of branched calcareous spicules.

Endostyle also strengthened by numerous branched calcareous spicules.

Dorsal lamina represented by a series of triangular languets.

Tentacles compound.

Alimentary canal relatively small, placed posteriorly on the left side; stomach ventral, intestine turned anteriorly and dorsally, and rectum running posteriorly.

Gonads on the inner face of the wall of the peribranchial cavity, developed on both sides of the body.

This is one of the most remarkable and characteristic of the abyssal genera of Ascidians. The seven known species were all discovered during the voyage of the 'Challenger.'

The species may be distinguished by external features as follows *:—

* For a table of distinguishing characters taken from internal structure, see 'Challenger' Report, part i. p. 126.

{ Peduncle turned posteriorly 1
{ Peduncle turned anteriorly 2

1 { Dorsal end fringed with papillæ ... *C. recumbens*, Herdm. (A. Arct.)
{ Dorsal end not fringed .... *C. perlucidus*, Herdm. (A. Arct.)

2 { Dorsal end fringed with papillæ.. 3
{ Dorsal end not fringed.. 4

3 { Surface even .... *C. perlatus* *, Suhm. (N. Atl.)
{ Surface very uneven .... *C. Murrayi*, Herdm. (N. Pac.)

4 { Atrial aperture on dorsal edge behind middle. *C. Willemoesi*, Herdm. (N. Pac.)
{ Atrial aperture in centre of posterior end 5

5 { Surface even .... *C. Moseleyi*, Herdm. (Pac.)
{ Surface very uneven, but smooth ... *C. Wyville-Thomsoni*, Herdm. (S. Pac.)

Subfamily Cynthiinæ, *Herdman*, 1880.

Body attached, sessile or very shortly pedunculated. Branchial and atrial apertures with 4 lobes each.

Test coriaceous, rarely cartilaginous, rarely covered with sand.

Branchial sac with more than 4 folds upon each side (except *Forbesella tessellata*, Forbes).

Tentacles compound.

Alimentary canal with no marked stomach, but with a glandular lobed appendage.

There are four genera :—*Microcosmus*, *Cynthia*, *Forbesella*, and *Rhabdocynthia*. The last is a new genus which I am forming for the reception of all those species of *Cynthia* which are provided with needle-like or rod-like spicules of carbonate of lime scattered through their tissues; and *Forbesella* is a new genus which I consider necessary for the remarkable *Cynthia tessellata* of Forbes, which differs from all other Cynthiinæ in having only 4 folds on each side of the branchial sac.

{ With only 4 folds present on each side .... **Forbesella.**
{ With more than 4 folds on each side 1

1 { Dorsal lamina plain, intestinal loop narrow .... **Microcosmus.**
{ Dorsal lamina toothed, intestinal loop wide 2

2 { Rod-like or curved calcareous spicules in tissues... **Rhabdocynthia.**
{ No such spicules present .... **Cynthia.**

* *Culeolus Tanneri*, Verr. (N. Atl.), is close to this species It may be distinct, but has not yet been fully described.

Microcosmus, *Heller*, 1877.

Body attached, sessile, not incrusted with a continuous coating of sand. Apertures both 4-lobed. A fold of the mantle, covered by the invaginated test, usually present at the base of the siphons.

Test coriaceous, thin but tough.

Branchial sac with more than 4 folds upon each side.

Dorsal lamina a plain untoothed membrane.

Tentacles compound.

Intestine forming a narrow loop, on the left side of the body.

Gonads on both sides, on the left partly covering the intestine.

The species of *Microcosmus* may be distinguished as follows:—

	Branchial sac with 5 folds on each side. *M. oligophyllus*, Heller. (S. Atl.)	
	Branchial sac with more than 5 folds on each side	1
1	Branchial sac with 6 folds on each side..	2
	Branchial sac with more than 6 folds on each side	3
2	Tentacles fewer than 12.............. *M. gleba*, Traust. (Pac.)	
	Tentacles 20, or more	4
4	Tentacles 20; dorsal tubercle simple, cordate. *M. Helleri*, Herdm. (Austr.)	
	Tentacles 28; dorsal tubercle complex, formed of 2 spiral cones. *M. Herdmani*, v. Dr. (S. Atl.)	
3	Branchial sac with 7 folds on each side	5
	Branchial sac with more than 7 folds on each side	6
5	With not more than 6 or 7 stigmata in a mesh............................	7
	With about 12 stigmata in a mesh... *M. propinquus*, Herdm. (Austr.)	
7	With 4–5 stigmata in a mesh	8
	With 6–7 stigmata in a mesh ...... *M. anchylodeirus*, Traust. (W. Ind.)	
8	Surface of test rough, corrugations irregular and granular	9
	Surface not so rough, corrugations regular and smooth	10
9	With an extraordinarily long branchial siphon. *M. scrotum*, D. Ch. (Med.)	
	Branchial siphon not very long ...... *M. polymorphus*, Heller. (Med. & Austr.)	
10	Pinnæ of the tentacles unbranched, 12–14 bars on branchial fold. *M. vulgaris*, Heller. (Atl. & Med.)	
	Pinnæ of the tentacles bearing small pinnules, 18–20 bars on fold. *M. Sabatieri*, Roule. (Med.)	
6	Branchial sac with 8 folds on each side	11
	Branchial sac with more than 8 folds on each side	12
11	With 16–20 tentacles, surface rough. *M. exasperatus*, Heller. (W. Ind.)	
	With 20–25 tentacles, surface nearly smooth. *M. distans*, Heller. (W. Ind.)	
12	Branchial sac with 9–10 folds on each side	13
	Branchial sac with 12 or more folds on each side	14
13	The 3 lower folds do not reach œsophageal aperture. *M. variegatus*, Heller. (Med., W. Ind.)	
	All the folds extending beyond the œsophageal aperture	15

15 { With 14–16 tentacles .... *M. claudicans*, Sav. (N.W. Eur., Pac., Med., Ind. O.)
With 18–20 tentacles .... *M. affinis*, Heller. (Austr.)

14 { With 14 folds on each side .... *M. Julinii*, v. Dr. (Austr.)
With 12 folds on each side .... *M. Draschii*, n. sp. (Austr.)

RHABDOCYNTHIA*, n. gen.

Body generally smooth. Branchial and atrial apertures 4-lobed.

Test generally rather soft and cartilaginous, containing calcareous spicules.

Mantle also containing calcareous spicules developed in connective-tissue sheaths.

Branchial sac with six or more folds on each side. The chief vessels contain calcareous echinated spicules.

Tentacles compound.

Dorsal lamina toothed.

There are about a dozen species in this genus, and they may be separated as follows:—

{ Branchial sac with 6 folds on each side 1
More than 6 folds on each side 2

1 { Surface smooth, test gelatinous, colour whitish. *R. mollis*, n. sp. (Austr.)
Surface corrugated, test leathery, colour dark brown. *R. sacciformis*, v. Dr. (Jap.)

2 { Test transparent or semitransparent 3
Test not at all transparent 4

3 { 7 folds on each side 5
8 folds on each side...................... *R. mauritiana*, v. Dr. (Ind. O.)

5 { Body elongated; colour greenish brown. *R. subfusca*, n. sp. (Austr.)
Body rounded, flattened; colour whitish. *R. tenuis*, n. sp. (Austr.)

4 { Test soft, cartilaginous 6
Test not soft or cartilaginous 7

6 { Test thin, surface roughish............ *R. papietensis*, Herdm. (Pac.)
Test thick, surface smooth .... *R. complanata*, Herdm. (Austr.)

7 { Animal barrel-shaped; colour red ... *R. rosea*, Sluit. (Mal.)
Not barrel-shaped; colour grey or yellowish white........................ 8

8 { Shape pyriform .... *R. pyriformis*, Rathke. (Pac., Atl.)
Shape oblong, with a broad base, 8 folds on each side. *R. pallida*, Heller. (Pac., Atl., W. Ind., Ind. O.
do., var. *billitonensis*, Sluit. (Mal.)

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* If this is exactly the genus for which Lahille, in 1887, proposed the name *Herdmania* (Assoc. Franç.), then *Rhabdocynthia* must give way to that prior designation.

CYNTHIA *, *Savigny*, 1816.

Body attached, sessile or very shortly stalked, rarely incrusted with sand. Branchial and atrial apertures both 4-lobed.

Test coriaceous, rarely cartilaginous; no spicules.

Mantle well-developed, usually with a strong musculature.

Branchial sac with 6 to 12 longitudinal folds on each side. No spicules in walls of vessels.

Dorsal lamina a plain membrane, or with the free margin toothed, or represented by a series of dorsal languets.

Tentacles always compound.

Intestine forming rather a wide loop, on the left side.

Gonads on both sides, the left in the intestinal loop.

	Branchial folds only slightly developed.	*C. irregularis*, Herdm. (Austr.)
	Branchial folds all well developed	1
1	Body pedunculated	2
	Body sessile	3
2	Test thick and tough	4
	Test thin and leathery	5
4	Surface sulcated	*C. cerebriformis*, Herdm. (Austr.)
	Surface incrusted with sand and hairs.	*C. japonica*, Traust. (Jap.)
5	Surface smooth, with silky spines	*C. formosa*, Herdm. (Austr.)
	Surface not smooth, having knobs and warts	6
6	Mantle thin, muscles weak; tentacles 50.	*C. castaneiformis*, v. Dr. (N. Pac.)
	Mantle strong and muscular; tentacles less than 30	7
7	Dorsal lamina having languets the entire length	8
	Dorsal lamina having languets only at posterior end.	*C. Roretzii*, v. Dr. (Jap.)
8	Meshes very much elongated transversely; tentacles 25–30; apertures fringed with bristles	*C. papillosa*, L. (Med., N. Atl.)
	Meshes not elongated; tentacles 16–20.	*C. stolonifera*, Heller. (S. Atl.)
3	Test more or less covered with sand	9
	Test free from sand	10
9	Body free	*C. arenosa*, Herdm. (Austr.)
	Body attached	11
11	Body columnar, with remarkable pad-like thickening of test anteriorly.	*C. præputialis*, Heller. (Austr.)
	Body not columnar, and with no such thickening.	*C. jacatrensis*, Sluit. (Mal.)
10	Test provided with remarkable long branched spines	12
	Test with no such branched spines	13

* *Halocynthia*, Verrill, is merely a synonym.

12 { Dorsal lamina a plain membrane ... *C. echinata*, L. (N. Atl.)
With two rows of small languets ... *C. Hilgendorfii*, Traust. (Jap.)

13 { Languets confined to posterior end, 6 branchial folds. *C. dura*, Heller. (Atl., Pac., & [Med.)
Languets along the whole length of dorsal lamina 14

14 { Not more than 6 folds on each side of the branchial sac 15
More than 6 folds on each side 16

15 { Reproductive organs in the form of numerous small scattered masses attached to mantle .... *C. corallina*, Roule. (Med.)
Reproductive organs not broken up into numerous separate masses ... 17

17 { Intestinal loop narrow .... *C. lævigata*, Heller. (W. Ind.)
Intestinal loop wide 18

18 { Test thin 19
Test not thin 20

19 { Surface smooth .... *C. clavigera*, Traust. (S. Atl.)
Surface not smooth 21

21 { Branchial siphon with a strong muscle-band at its base and armed with spines .... *C. nodulosa*, v. Dr. (W. Ind. ?)
Branchial siphon not provided with this armature 22

22 { Inner surface of test white, soft...... *C. squamulosa*, Ald. (N.W. Eur. [& Med.)
Inner surface not white, nor soft.. 23

23 { Internal longitudinal bars regular, 13–15 on a fold, 7 stigmata in mesh. *C. Riisiana*, Traust. (W. Ind.)
Internal longitudinal bars irregular, 5 or 6 stigmata in mesh. *C. haustor*, Stimps. (N. Pac.)

20 { Tentacles 20–30, test smooth 24
Tentacles 12, test rough .... *C. fissa*, Herdm. (Austr.)

24 { Apertures inconspicuous, far apart . *C. gangelion*, Sav. (Red S.)
Apertures conspicuous .... *C. arcuata*, Heller. (Austr.)

16 { Test cartilaginous, smooth 25
Test coriaceous and rough 26

25 { More than 10 folds on each side of branchial sac. *C. hispida*, Herdm. (Austr.)
Not more than 9 folds on each side 27

27 { Mantle semitransparent, tentacles 12. *C. momus*, Sav. (Med., Red S., Atl.)
Mantle opaque, tentacles 24–28, 7 branchial folds on each side. *C. pantex*, Sav. (Red S.)

26 { Not more than 10 branchial folds on each side............................. 28
12 or 13 folds on each side........... *C. grandis*, Heller. (Austr.)

28 { Apertures at opposite ends of body . *C. mirabilis*, v. Dr. (Jap.)
Apertures not distant 29

29 { Body oblong, erect, long axis antero-posterior. *C. Nordenskioldii*, Wagn. (Arct.)
Body rounded, or quadrangular with long axis transverse 30

30 { Body rounded, mamillated, red, siphons striped with orange. *C. morus*, Forb. (N.W. E. & Med.)
Body not rounded and not red 31

31 { Body ovoid or retort-shaped .... *C. scutellata*, Heller. (Med.)
Body quadrangular .... *C. galbana*, n. sp. (Austr.)

For insufficiently described forms see p. 585.

Forbesella, n. gen.

Body attached, depressed.

Test firm, modified to form scales or plates.

Branchial sac with only 4 folds on each side, or even only 3 on the left side.

Tentacles compound.

This genus is formed for the reception of the remarkable little "*Cynthia tessellata*" of E. Forbes, which differs from all other known Cynthiinæ and agrees with the Styelinæ (from which again it differs in having compound tentacles) in having not more than 4 folds on each side of the branchial sac. The "*Cynthia limacina*" of Forbes is either the same species or very closely related to it, and probably therefore comes also into this genus.

The single sufficiently known species is then

Forbesella tessellata, Forb. (N.W. Eur.)

Subfamily Styelinæ, *Herdman*, 1881.

Body attached, sessile, rarely incrusted with sand. Branchial and atrial apertures either 4-lobed or irregular.

Test usually coriaceous, rarely cartilaginous.

Branchial sac with at most four folds upon each side.

Tentacles simple, unbranched.

Alimentary canal with a well-marked stomach and no distinct glandular cæcum or "liver."

Gonads in the form of one or a few elongated tubes, or a large number of small scattered masses ("polycarps") attached to the inner surface of the mantle.

This subfamily includes 8 genera*, which may be distinguished as follows:—

	Branchial sac absent †	**Styeloides.**
	Branchial sac present	1
1	Branchial sac with no folds	**Pelonaia.**
	Branchial sac with folds	2
2	Branchial sac with no stigmata in the meshes	**Bathyoncus.**
	Branchial sac with stigmata in the meshes	3
3	With only a single fold in the branchial sac	**Styelopsis.**
	With more than one fold in the branchial sac	4

* *Alderia*, proposed by Lahille in 1887, cannot be conveniently separated from *Styela*.

† This is such an exceptional and remarkable case that I cannot help suspecting that the single specimen examined by Sluiter was merely an individual abnormality.

4	With a single gonad, placed on the right side .... **Dendrodoa.**	
	With gonads on both sides	5
5	Stigmata curved .... **Glandula.**	
	Stigmata straight	6
6	Gonads few, elongated, tubular .... **Styela.**	
	Gonads numerous, small "polycarps" .... **Polycarpa.**	

STYELOIDES, *Sluiter*, 1885.

Branchial sac entirely absent.

Tentacles simple.

Alimentary canal absent.

This includes a single species, *Styeloides abranchiata*, a remarkable form found by Sluiter near the island of Billiton in the Malay Archipelago.

PELONAIA, *Forbes and Goodsir*, 1841.

Body cylindrical, elongated, unattached. Apertures anterior, not lobed.

Test coriaceous, wrinkled, partly incrusted with sand.

Branchial sac with no folds.

This genus includes two forms which may be separate species, viz. :—

Body much elongated; surface rough, wrinkled, deep brown.
P. corrugata, Forb. (N.W. Eur.)
Not so much elongated; surface smooth, pilose, greenish yellow.
P. glabra, Forb. & Goods. (N.W. Eur.)

BATHYONCUS, *Herdman*, 1882.

Body ovate or discoid, sessile, attached; apertures inconspicuous.

Test membranous and thin.

Branchial sac with several slight folds on each side; meshes square, no stigmata nor fine longitudinal vessels.

Dorsal lamina a plain membrane.

Tentacles simple.

Alimentary canal on the left side.

Gonads a single elongated mass or several small masses attached to the mantle on each side.

This is a very remarkable and entirely deep-sea genus. It contains three species, all obtained during the 'Challenger' Expedition, and all from very deep water, viz. 1600, 2300, and 3125 fathoms, the latter being the greatest depth, I believe, from which Ascidians have ever been obtained.

The three species may be separated as follows:—

	With one large fold on left side of branchial sac; body ovate. *B. mirabilis*, Herdm. (Southern Oc.)	
	With small folds only	1
1	Body discoid .... *B. discoideus*, Herdm. (N. Pac.)	
	Body globular .... *B. minutus*, Herdm. (N. Pac.)	

STYELA, *MacLeay*, 1824.

Body attached, sessile, rarely pedunculated, sometimes incrusted with sand. Apertures both 4-lobed.

Test usually thin, coriaceous.

Branchial sac with 4, or fewer, folds on each side.

Dorsal lamina usually with a plain margin.

Tentacles simple, unbranched.

Alimentary canal forming a narrow loop.

Gonads on both sides of the body. Ovaries in the form of elongated sausage-like bodies.

The known species of *Styela* may be arranged as follows:—

	Branchial folds partly rudimentary	1
	Branchial folds all well developed	2
1	Dorsal lamina plain	3
	Dorsal lamina not a plain membrane	4
3	Two or 3 distinct branchial folds on each side	5
	Four slight folds on each side	6
5	Colour cream-white; test thick but soft, scaly. *S. squamosa*, Herdm. (A. Arct.)	
	Colour dark brown; test tough, wrinkled. *S. pusilla*, Herdm. (N. Pac.)	
6	Body flattish, longer than high ...... *S. humilis*, Heller. (S. Pac.)	
	Body acorn-shaped, as high as long. *S. glans*, Herdm. (S. Atl.)	
4	Margin of dorsal lamina crumpled	7
	Margin of dorsal lamina notched and toothed. *S. flava*, Herdm. (S. Atl.)	
7	Atrial aperture far back; surface covered with silky hairs. *S. sericata*, Herdm. (A. Arct.)	
	Atrial aperture anterior; surface rough and slightly sandy, no hairs. *S. oblonga*, Herdm. (S. Atl.)	
2	Body covered with sand	8
	Body not covered with sand	9
8	More or less sandy all over	10
	Sand confined to posterior half ...... *S. bicolor*, Sluit. (Mal.)	
10	Individuals aggregated in clusters, test coriaceous. *S. racemosa*, n. sp. (Austr.)	
	Individuals not aggregated, test rather cartilaginous *. *S. exigua*, Herdm. (Austr.)	

* Here also *Styela perforata* and *Styela Traustedti*, both from the Malay Archipelago, the description of which by Sluiter has reached me since this table was in type, find their place; they can be readily distinguished from *S. exigua*.

9	Body on a well-marked peduncle	11
	Body sessile	12
11	Peduncle slender, meshes with 6 or more stigmata. *S. clava*, Herdm. (N. Pac.)	
	Peduncle not very slender, meshes with only 2 stigmata. *S. gelatinosa*, Traust. (Arct.)	
12	Languets present ...... *S. bythia*, Herdm. (A. Arct.)	
	Dorsal lamina a plain membrane	13
13	Test with hair-like prolongations from surface	14
	Test with no such prolongations	15
14	Black on surface, hairs few and large. *S. solearis*, Sav. (Red S.)	
	Grey, hairs small and felted ...... *S. cinerea*, Sav. (Red S.)	
15	Dorsal tubercle large and complicated. *S. mytiligera*, Sav. (Red S.)	
	Dorsal tubercle not large nor complicated	16
16	Very many stigmata in a mesh	17
	Meshes not exceedingly elongated	18
17	Body pyriform, apertures with more than 4 lobes. *S. grandis*, Herdm. (A. Arct.)	
	Body barrel-shaped, apertures, 4-lobed. *S. lactea*, Herdm. (A. Arct.)	
18	Individuals aggregated	19
	Individuals not aggregated	20
19	Surface sulcated, of a white colour... *S. plicata*, Les. (Cosmop.) (=*S. gyrosa*, Hell.)	
	Surface not sulcated, of a reddish colour. *S. aggregata*, O.F.M. (N.W.Eur.)	
20	Stigmata 3 in a mesh ...... *S. convexa*, Herdm. (A. Arct.)	
	Stigmata more than 3 in a mesh	21
21	Meshes not divided transversely	22
	Meshes divided transversely	23
22	Body broad (dorso-ventrally)...... *S. scortea*, n. sp. (Austr.)	
	Body long (antero-posteriorly) ...... *S. radicosa*, Herdm. (Austr.)	
23	Colour pale yellowish grey, siphons violet inside. *S. canopus*, Sav. (Red S.)	
	Colour red, siphons not violet inside. *S. canopoides*, Heller. (Med.)	

For imperfectly known species, see p. 585.

STYELOPSIS, *Traustedt*, 1882.

Body globular or cylindrical, attached, not incrusted with sand. Apertures both 4-lobed.

Branchial sac with the folds reduced to a single one placed near the dorsal edge of the right side, the other 7 being quite rudimentary.

Gonads on the right side only.

This genus was formed for the reception of the single species *Styelopsis grossularia*, Van Beneden, common on the north-western shores of Europe.

DENDRODOA, *MacLeay*, 1824.

Body subcylindrical, attached, not sandy. Apertures minute, on anterior end.

Test coriaceous.

Branchial sac with 4 folds on each side.

Tentacles simple.

Alimentary canal on left side, stomach grooved, intestinal loop narrow.

Gonads forming a single branched mass placed on the right * side of the body on the inner surface of the mantle.

This genus contains the single species *Dendrodoa glandaria*, MacLeay, from Winter Island (Arct.).

GLANDULA, *Stimpson*, 1852.

Body free, globular, sandy. Branchial and atrial apertures both 4-lobed.

Branchial sac with 4 folds on each side. Stigmata curved and arranged in elliptic groups round centres which are placed in longitudinally-running rows.

Dorsal lamina plain-edged.

Tentacles simple.

Alimentary canal on the left side.

Gonads forming 5 long masses on the right and 3 on the left side.

This genus, which comes close to *Styela*, but differs from it in having the stigmata curved, has had the following three species placed in it; but they require re-examination, and may possibly prove to belong to one and the same species:—

G. mollis, Stimpson. (E. N. Am.)
G. fibrosa, Stimps. (E. N. Am.
G. arenicola, Verrill. (E. N. Am.)

POLYCARPA, *Heller*, 1877.

Body attached, usually sessile, rarely pedunculated, sometimes incrusted with sand. Both apertures usually 4-lobed.

Test usually coriaceous.

Branchial sac with 4 folds, or less than 4, on each side.

Dorsal lamina with a plain margin.

Tentacles simple.

Alimentary canal forming a wide loop.

Reproductive organs in the form of a number of small separate

* "Left" in MacLeay's description (Trans. Linn. Soc. vol. xiv. p. 548), as he described the animal in the reversed position.

masses ("polycarps") scattered over the inner surface of the mantle.

The known species of *Polycarpa* * may be arranged thus:—

	Branchial sac with folds rudimentary	1
	Branchial sac with folds well developed	2
1	Test very thin, 2 bars on each fold, 6–8 stigmata. *P. minuta*, Herdm. (A. Arct.)	
	Test thick, bars on fold numerous, 1–4 stigmata. *P. quadrata*, Herdm. (Mal.)	
2	Less than 4 folds on each side..	
	At least 4 folds on each side	4
3	With 2 folds on each side .... *P. simplex*, n. sp. (Austr.) [Med.)	
	With 3 on right side and 2 on left. *P. glomerata*, Ald. (N.W. Eur.,	
4	With 5 folds on right side and 4 on left	5
	With 4 folds on each side..	6
5	Test thick; one horn of dorsal tubercle turned out. *P. spongiabilis*, Traust. (W. Ind.)	
	Test thin, pellucid; both horns of dorsal tubercle turned in. *P. obtecta*, Traust. (W. Ind.)	
6	Branchial sac papillated on inner surface	7
	No papillæ on interior of branchial sac..	8
7	Tentacles 25, stigmata normal ... *P. papillata*, Sluit. (Mal.)	
	Tentacles 40, stigmata small round apertures. *P. Herdmani*, Sluit. (Mal.)	
8	Body pedunculated	9
	Body sessile	10
9	Individuals aggregated in masses. *P. nigricans*, Heller. (Ind. O.)	
	Individuals not aggregated	11
11	5–12 stigmata in a mesh	12
	13 or 14 stigmata in a mesh ...... *P. spiralis*, Sluit. (Mal.)	
12	Peduncle almost as long as body	13
	Peduncle much shorter than body	14
13	Apertures conspicuous, branchial anterior, atrial dorsal, lobes distinct. *P. pedata*, Herdm. (Mal.)	
	Apertures inconspicuous, both anterior, lobes indistinct. *P. radicata*, Herdm. (Austr.)	
14	More than 65 tentacles .... *P. viridis*, Herdm. (Austr.)	
	Fewer than 50 tentacles	15
15	Body roundish, attached posteriorly by branching roots, some adhering sand .... *P. pedunculata*, Heller. (Austr.)	
	Body longish, no adhering roots, surface almost smooth..................	16
16	Mantle thin, muscles weak, dorsal lamina wide, anterior part sinuous. *P. oligocarpa*, Sluit. (Mal.)	
	Mantle thick, muscles strong, dorsal lamina smooth and straight. *P. elata*, Heller. (Austr. & Mal.)	
10	Body all covered with sand	17
	Body not sandy, or only partially covered	18
17	4–6 bars on a fold, 1 or 2 in the interspace. *P. pusilla*, Herdm. (N.W. Eur.)	
	6–9 bars on a fold, 6–8 in the interspace	19

* *Styela psoloessa*, *S. aurita*, *S. argentata*, and *S. olitoria*, recently described by Sluiter from the Malay Archipelago, too late for insertion in the table, fall into this genus according to my definitions.

19	2 or 3 stigmata in a mesh	*P. procera*, Sluit. (Mal.).
	4–10 stigmata in a mesh	20
20	Siphons very long	*P. longisiphonica*, Herdm. (Austr.)
	Siphons not unusually long	21
21	Test prolonged into branched hair-like processes	22
	Test not provided with these processes or fibres	23
22	Apertures close, conspicuous, yellow speckled with red.	*P. comata*, Ald. (N.W. Eur.)
	Apertures distant, inconspicuous, dark brown colour.	*P. molguloides*, Herdm. (Austr.)
23	Individuals very small, like pellets of sand.	*P. pilella*, Herdm. (S. Atl.)
	Individuals not small	24
24	Test having processes for attachment; tentacles 16–20.	*P. sabulosa*, Heller. (Med.)
	No processes of test for attachment present	25
25	Atrial aperture at anterior end	*P. tinctor*, Q. & G. (Austr.)
	Atrial aperture at posterior end	*P. Stimpsoni*, Heller. (Austr.)
18	Dorsal lamina a plain membrane	26
	Dorsal lamina not a plain membrane	27
27	Dorsal lamina ribbed only in the anterior part.	*P. captiosa*, Sluit. (Mal.)
	Dorsal lamina with partial ribs along the entire length.	*P. formosa*, Herdm. (N. Atl.)
26	Tentacles numerous, 60 or more	28
	Tentacles not numerous, 40 or less	29
28	Dorsal tubercle irregularly horseshoe-shaped, one horn turned out.	*P. rugosa*, v. Dr. (S. Atl.)
	Dorsal tubercle nearly circular, horns turned in.	*P. pomaria*, Sav. (N.W. Eur.)
29	Body free, covered with sand, &c.	30
	Body attached, test exposed or only partially incrusted	31
30	Surface smooth, regular, fine sand grains; colour yellow-brown.	*P. curta*, Herdm. (N. Atl.)
	Surface rough, irregular, stones &c. attached; colour dull yellow.	*P. monensis*, Herdm. (N.W. Eur.)
31	Test cartilaginous, with bladder-cells.	*P. ascidioides*, n. sp. (Austr.)
	Test not cartilaginous, no bladder-cells	32
32	Test quite black	33
	Test not black	34
33	Fixed by shaggy fibres, foreign matter attached.	*P. obscura*, Heller. (Austr.)
	Test with no fibres, surface free from foreign matter.	*P. cryptocarpa*, Sluit. (Mal.)
34	Body discoid, flattened antero-posteriorly, tentacles 16.	*P. discoidea*, Heller. (Med.)
	Body not flattened antero-posteriorly	35
35	Surface nearly smooth	36
	Surface irregular and crumpled, or mamillated	37
36	Shape ball-like	*P. tumida*, Heller. (W. Ind.)
	Shape not ball-like	38
38	Posterior end narrow	39
	Posterior end broad and rounded	40

40 { Alimentary canal forms a very wide loop, open dorsally. *P. patens*, Sluit. (Mal.)
Alimentary canal not forming a wide loop. *P. Haddoni*, n. sp. (Austr.)

39 { Colour dark, though not black ... *P. nebulosa*, Heller. (Austr.)
Colour light, yellowish or greyish white 41

41 { Anus fringed, stomach ovate ...... *P. argoensis*, Herdm. (N.W. Eur.)
Anus not fringed, stomach elliptical. *P. gracilis*, Heller. (Med.)

37 { Test tough and leathery 42
Test soft, may be thick 43

43 { Dorsal tubercle spongy and irregular. *P. sulcata*, Herdm. (Mal.)
Dorsal tubercle not spongy, normal 44

44 { Dorsal tubercle circular in outline. *P mollis*, Heller. (?)
Dorsal tubercle irregularly S-shaped. *P. elongata*, n. sp. (Austr.)

42 { Tentacles all one length .... *P. rigida*, Herdm. (Austr.)
Tentacles of different lengths 45

45 { Meshes divided by a horizontal vessel 46
Meshes not divided horizontally...... 47

47 { Stigmata 6–8 in a mesh 48
Stigmata 10–12 in a mesh .... *P. Bassi*, Herdm. (Austr.)

48 { Test thick and tough 49
Test thin ...... *P. torresiana*, n. sp. (Austr.)

49 { Colour dirty yellowish white...... *P. irregularis*, Herdm. (Mal.)
Colour dark purplish brown 50

50 { Inner surface of mantle with minute brown pigment-spots. *P. ænea*, n. sp. (Austr.)
Inner surface of mantle without pigment-spots. *P. fulva*, n. sp. (Austr.)

46 { Siphons prominent and conspicuous 51
Siphons not prominent or conspicuous 52

51 { Test thin; stigmata 7–8 in a mesh. *P. Mayeri*, Traust. (Med.)
Test thick and opaque; stigmata 3 in a mesh. *P. aspera*, Herdm. (S. Atl.)

52 { Body cylindrical, colour red ...... *P. rustica*, Linn. (N.W. Eur.)
Body not cylindrical, colour brownish 53

53 { Inner surface of test pearly grey-white; stigmata 10–12 in a mesh. *P. varians*, Heller. (Med.)
Inner surface of test light brown, with dark specks; stigmata 7–9 in a mesh ...... *P. fastigata*, n. sp. (Austr.)

The following species of Cynthiidæ have been so insufficiently described that it is impossible to say with certainty which genera they belong to:—

Cynthia quadrangularis, Forb. (N.W. Eur.)
C. informis, Forb. (N.W. Eur.)
C. limacina, Forb. (N.W. Eur.) [? *Forbesella*.]
C. mammillaris, Pallas. (N.W. Eur.)
C. ampulla, Brug. (N.W. Eur., Med.)

C. tuberosa *, Macg. (N.W. Eur., Med.)
C. sabulosa, Stimps. (Austr.) [Styelinæ.]
C. partita, Stimps. (E. N. Am.)
C. ovalis. (?)
C. violacea, Ald. (N.W. Eur.)
C. coriacea, Ald. & Hanc. (N. W. Eur.)
C. sulcatula, Ald. (N.W. Eur.)
C. granulata, Ald. (N.W. Eur.)
C. monoceros, Möll. (E. N. Am.)
C. carnea, Ag. (E. N. Am.)
C. stellifera, Verr. (E. N. Am.)
C. pulchella, Verr. (E. N. Am.)
C. opalina, Ald. (N.W. Eur.)
C. glacialis. (?)
C angularis, Stimps. (S. Atl.)
C. lævissima, Stimps. (Austr.) [Cynthiinæ.]
C. dumosa, Stimps. (Austr.) [Cynthiinæ.]
C. satsumensis, Stimps. (Japan.)
C. delicatula, Stimps. (? Japan.)
C. ocellifera, Stimps. (China.)
C. gemmata, Stimps. (China.)
C. araneosa, Stimps. (China.)
C. pupa, Sav. (Red S.) [*Microcosmus* ?]
C. rosea, Ald. (N.W. Eur.)
Styela pupa, Heller. (S. Atl.)
S. areolata, Heller. (Ind. O.)
S. lineata, Beck. (Arct.)
S. variabilis. (?)
S. fibrillata. (?)

Family III. ASCIDIIDÆ, *Herdman*, 1880.

Body attached, usually sessile, rarely pedunculated. Branchial aperture usually 8-lobed, atrial usually 6-lobed.

Test gelatinous or cartilaginous, rarely chitinaceous or horny.

Branchial sac without folds. Internal longitudinal bars present and usually papillated. Stigmata straight or curved.

Tentacles simple, filiform.

Alimentary canal either at one side of the branchial sac (usually the left) or extending beyond it posteriorly.

Gonads placed close to the intestine.

There are four subfamilies—the Corellinæ, the Hypobythiinæ, the Ascidiinæ, and the Cioninæ.

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* This species is described as having 6 folds on each side of the branchial sac, and simple tentacles.

Subfamily CORELLINÆ, *Herdman*, 1882.

Body attached, sessile or pedunculated. Branchial aperture with 8, 6, or no lobes.

Test cartilaginous, gelatinous or horny.

Branchial sac provided with internal longitudinal bars. Stigmata curved.

Alimentary canal usually on right side or dorsal edge of branchial sac.

This subfamily contains 3 genera which may be separated as follows:—

	Test modified to form horny (chitinaceous) plates ...	**Chelyosoma.**
	Test soft and gelatinous or cartilaginous	1
1	Body sessile; viscera on right side of branchial sac	**Corella.**
	Body pedunculated; viscera on dorsal edge of branchial sac.	**Corynascidia.**

CHELYOSOMA, *Brod. & Sow.*, 1829.

Body flattened antero-posteriorly, depressed and attached. Branchial and atrial apertures both 6-lobed.

Test modified on the upper surface to form polygonal horny plates, definite in shape and position.

Branchial sac with curved stigmata.

Dorsal lamina represented by languets.

Alimentary canal on left side of branchial sac.

Gonads forming a network over the intestinal loop.

There are two known species:—

With the test of the upper surface divided into 8 plates.
C. Macleayanum, Brod. & Sow. (Atl., Arct., Pac.)

With the test of the upper surface divided into 14 plates.
C. productum, Stimps. (N. Pac.)

CORYNASCIDIA, *Herdman*, 1882.

Body elongated, pyriform, pedunculated. Apertures not lobed.

Test gelatinous or membranous.

Branchial sac extremely delicate. Internal longitudinal bars present, but not provided with papillæ. Interstigmatic vessels and stigmata coiled spirally.

Dorsal lamina represented by languets.

Tentacles simple, filiform.

Alimentary canal on dorsal edge of branchail sac, running antero-posteriorly.

Gonads forming a mass placed on the posterior end of stomach.

This genus contains the single 'Challenger' species*nas Corycidia Suhmi*, Herdman, of which specimens were obtained in the South Pacific from a depth of 2160 fms., and in the Antarctic from a depth of 1375 fms.

Corella, *Alder & Hancock*, 1870.

Body attached, occasionally free, sessile. Branchial aperture 8-lobed, atrial 6-lobed.

Test gelatinous or cartilaginous, but soft and semitransparent.

Branchial sac with no papillæ on its internal longitudinal bars. Stigmata curved and placed in the walls of regularly arranged infundibula; interstigmatic vessels spirally coiled.

Dorsal lamina represented by languets.

Tentacles simple.

Alimentary canal on the right side of the branchial sac.

Gonads forming a network round the median part of the intestine.

The species of *Corella* are as follows:—

	Atrial aperture anterior	1
	Atrial aperture dorsal	2
1	Atrial aperture placed on a very long projection. *C. larvæformis*, Hanc. (N.W. Eur.)	
	Atrial aperture sessile, or on a short siphon	3
3	Musculature strong on left side... *C. parallelogramma*, O.F.M. (N.W. Eur., Med.)	
	Musculature very weak on both sides. *C. minuta*, Traust. (W. Ind.)	
2	Anterior end wide, atrial aperture not far from branchial. *C. ovata*, Hanc. (N.W. Eur.)	
	Anterior end narrow, atrial aperture distant from branchial	4
4	Tentacles of more than one size	5
	Tentacles all of one size .... *C. japonica*, Herdm. (Pac., Mal.)	
5	Tentacles 50	6
	Tentacles over 100 .... *C. novaræ*, v. Dr. (Ind. O.)	
6	Tentacles of 2 sizes, dorsal tubercle horseshoe-shaped. *C. eumyota*, Traust. (S. Atl.)	
	Tentacles of 3 sizes, dorsal tubercle semilunar. *C. borealis*, Traust. (Arct.)	

Subfamily Hypobythiinæ, *Herdman*, 1882.

Body pedunculated, fixed. Apertures not lobed.

Test gelatinous or cartilaginous.

Branchial sac with no internal longitudinal bars. Stigmata small and irregular.

Viscera on dorsal edge of branchial sac.

This group contains the single genus *Hypobythius*.

HYPOBYTHIUS, *Moseley*, 1876 [& *Herdman*, 1882].

Body cup-shaped or pyriform, pedunculated, attached. Apertures circular, not lobed.

Test cartilaginous, but soft and thin, thickened in places to form plates.

Branchial sac not folded, and with no internal longitudinal bars. Stigmata small, rounded, and irregularly placed.

Dorsal lamina a plain membrane.

Viscera forming a compact elongated mass on the dorsal edge of the branchial sac.

This remarkable deep-sea genus contains two species, obtained during the 'Challenger' Expedition from depths of 2900 and 600 fms. :—

Body on a long peduncle; test thickened to form many rounded nodules or plates............................ *H. calycodes*, Mos. (N. Pac.)

Body on a short peduncle; test only thickened to form a single plate on dorsal edge .... *H. Moseleyi*, Herdm. (S. Atl.)

Subfamily ASCIDIINÆ, *Herdman*, 1882.

Body usually attached by left side or posterior end. Branchial aperture with at least 8 lobes; atrial with at least 6 lobes.

Test gelatinous or cartilaginous.

Mantle with the musculature forming an irregular network, which is strongest on the right side.

Viscera on the left side of the branchial sac.

Branchial sac provided with internal longitudinal bars. Stigmata straight.

Dorsal lamina usually a plain membrane, rarely languets (*Abyssascidia*).

This subfamily contains 5 genera, as follows:—

	Dorsal lamina present as a membrane	1
	Dorsal lamina represented by languets	**Abyssascidia.**
1	Branchial sac recurved posteriorly	**Phallusia.**
	Branchial sac straight	2
2	Nerve-ganglion close to dorsal tubercle	**Ascidiella.**
	Ganglion distant from dorsal tubercle	3
3	Test very hard, thick and stiff	**Pachychlæna.**
	Test soft and flexible	**Ascidia.**

PHALLUSIA (*Sav.*, 1816), *Roule*, 1884.

Body erect, attached.

Test cartilaginous.

Branchial sac with its posterior part recurved upon itself.

Nerve-ganglion and neural gland distant from the dorsal tubercle.

Dorsal lamina extending behind the œsophageal aperture.

Renal concretions always enclosed in the intestinal wall, and never extending into the mantle.

This contains the single well-known species *P. mammillata*, Cuv. (N.W. Eur., Med.).

ASCIDIELLA, *Roule*, 1884.

Body attached by posterior end or left side, not incrusted with sand. Branchial and atrial apertures not far distant.

Branchial sac with no intermediate papillæ on the internal longitudinal bars; not folded on itself posteriorly. Transverse vessels of two sizes, placed alternately.

Nerve-ganglion and subneural gland placed close behind the dorsal tubercle.

Dorsal lamina not continued posterior to the œsophageal aperture.

Renal concretions extending into the left side of the mantle as well as the intestinal wall.

The known species of *Ascidiella** may be separated as follows:—

	Branchial sac with papillæ	1
	No papillæ in branchial sac	2
1	With a very wide open intestinal loop. *A. archaia*, Sluit. (Mal.)	
	With the usual narrow intestinal loop. *A. venosa*, O. F. M. (N.W. Eur., Med.)	
2	Fixed by a posteriorly placed peduncle. *A. lutaria*, Roule. (Med.)	
	Not fixed by a posterior peduncle	3
3	Body triangular, wide posteriorly, narrow anteriorly. *A. triangularis*, Herdm. (N.W. Eur.)	
	Body nearly cylindrical or ellipsoidal	4
4	Dorsal lamina with a plain edge. *A. virginea*†, O. F. M. (N.W. E., Med.)	
	Dorsal lamina with the edge toothed or irregular	5

* Some of the older species of *Ascidia* which have not been re-investigated lately may belong to this genus. I place here provisionally the remarkable *Ascidia archaia* described lately by Sluiter from the Malay Archipelago. The position of the ganglion is not known. "*Phallusia scabroides*," named by Ed. Van Beneden and Julin, but not yet sufficiently described, appears to belong to this genus.

† The *Ascidia sordida* of Alder & Hancock.

5 { Attached by small area at posterior end, lobes of buccal siphon denticulated, stigmata 5 in a mesh. *A. aspersa**, O. F. M. (N.W. Eur. & Med.)
Attached by large area on left side, buccal lobes rounded, stigmata 12 in a mesh .... *A. scabra*, O. F. M. (N.W. Eur. & Med.)

ASCIDIA, *Linn.*, 1767.

Body attached, sessile, rarely pedunculated; free or incrusted with sand. Branchial and atrial apertures not close together; branchial 8-lobed, atrial 6-lobed †.

Test cartilaginous or membranous, soft or hard, usually crowded with large bladder-cells.

Branchial sac not folded on itself posteriorly; sometimes minutely plicated. The internal longitudinal bars usually bear papillæ. The stigmata are straight; three smaller transverse vessels between each pair of larger.

Nerve-ganglion and subneural gland distant from the dorsal tubercle.

Dorsal lamina a simple membrane which may be transversely ribbed and have marginal teeth, or may be perfectly plain. It is continued behind the œsophageal aperture.

Tentacles simple.

Alimentary canal on the left side of the branchial sac.

Gonads in the intestinal loop.

Renal concretions always contained in the intestinal wall, never extending into mantle.

{ Test completely invested with sand 1
Test not completely invested with sand 2

1 { Siphons short .... *A. conchilega*, O. F. M. (N.W. Eur.)
Siphons very long .... *A. involuta*, Heller. (Med.)

2 { Two individuals always found together in a common test. *A. diplozoon*, Sluit. (Mal.)
Individuals occurring separately.. 3

3 { Branchial sac not plicated 4
Branchial sac minutely plicated 5

4 { Stigmata exceeding 7 in a mesh. *A. Patoni*, Herdm. (N.W. Eur.)
Stigmata less than 7 in a mesh 6

6 { Tentacles numerous, about 60.. 7
Tentacles not numerous, about 40 8

7 { Dorsal lamina with plain edge, very slight ribs.......................... 9
Dorsal lamina with toothed edge and distinct transverse ribs........... 10

10 { Stomach ovate or globular 11
Stomach elongated and sausage-shaped. *A. dijmphniana*, Traust. (Arct.)

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* Including *Ascidia pustulosa*, Ald. & Hanc.

† Sluiter has just described a species, *Ascidia decemplex*, from the Malay Archipelago, with ten lobes round each aperture.

11 { Dorsal tubercle very small. *A. Salvatoris**, Traust. (Med.)
Dorsal tubercle large...... *A. glacialis*, Traust. (Arct.)

9 { Transverse vessels alternately large and small. *A. tritonis*, Herdm. (N. Atl.)
Transverse vessels all much same size 12

12 { Transverse vessels slender, apertures both anterior. *A. cylindracea*, Herdm. (Austr.)
Transverse vessels wide, atrial aperture some way back. *A. nodosa*, Sluit. (Mal.)

8 { Intermediate papillæ present. *A. tenera*, Herdm. (S. Atl. & Mag.)
No intermediate papillæ present.. 13

13 { Body very much elongated, siphons conspicuous. *A. curvata*, Traust. (W. Ind.)
Body not elongated, siphons inconspicuous 14

14 { Tentacles 20–25 .... *A. despecta*, Herdm. (A. Arct.)
Tentacles 35–40.. 15

15 { Dorsal tubercle simple, U-shaped. *A. exigua*†, Herdm. (N.W. Eur.)
Dorsal tubercle horseshoe-shaped. *A. falcigera*, Herdm. (N. Atl.)

5 { Plication of the branchial sac very slight 16
Plication strongly marked 17

16 { Apertures both near centre of upper surface. *A. aspera*, Heller. (Med.)
Apertures not in centre, but at dorsal edge. *A. muricata*, Heller. (Med.)

17 { Surface covered with short hairs. *A. capillata*, Sluit. (Mal.)
Surface free from hairs 18

18 { No papillæ on internal longitudinal bars. *A. patula*, O. F. M. (N.W. Eur.)
With internal longitudinal bars papillated 19

19 { Body erect, attached by small area posteriorly.............................. 20
Body recumbent, attached by greater part of left side 21

20 { Prebranchial zone with papillæ 22
Prebranchial zone not papillated 23

22 { Papillæ of prebranchial zone very large. *A. melanostoma*, Sluit. (Mal.)
Papillæ small.............. *A. prunum*, O. F. M. (N.W. Eur. & Med.)

23 { Tentacles numerous, 60 or more... 24
Tentacles not numerous, 25 to 35 25

24 { Test very dark coloured 26
Test not of a dark colour... 27

26 { Intermediate papillæ on the internal longitudinal bars. *A. nigra*, Sav. (Atl., Red S.)
No intermediate papillæ on the bars. *A. atra*, Les. (W. Ind.)

27 { Body free, not attached 28
Body attached 29

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* This is the *A. oblonga* of Traustedt's former paper.

† This may possibly be the young of some other species.

28 { Dorsal tubercle irregular, aperture broken up into 4 distinct sections. *A. liberata*, Sluit. (Mal.)
Dorsal tubercle normal, aperture not broken up. *A. limosa*, Sluit. (Mal.)

29 { Body pear-shaped .... *A. pyriformis*, Herdm. (Austr.)
Body not pear-shaped 30

30 { Dorsal tubercle semilunar in shape 31
Dorsal tubercle not semilunar.................................... 32

31 { Test transparent .... *A. styeloides*, Traust. (W. Ind.)
Test thick and soft, not transparent. *A. meridionalis*, Herdm. (S. Atl.)

32 { Atrial aperture not more than ¼ way down body. *A. Challengeri*, Herdm. (A. Arct.)
Atrial aperture more than ¼ way down body. *A. mentula**, O. F. M. (N.W. Eur. & Med.)

25 { Dorsal tubercle longer antero-posteriorly than laterally 33
Dorsal tubercle longer laterally than antero-posteriorly 34

34 { Dorsal tubercle heart-shaped. *A. truncata*, Herdm. (N.W. Eur.)
Dorsal tubercle serpentiform. *A. translucida* †, Herdm. (A. Arct.)

33 { Stigmata 2–6 in a mesh... *A. fusiformis* ‡, Herdm. (N.W. Eur.)
Stigmata 6–8 in a mesh.................................... 35

35 { Test soft, easily torn; stigmata long and narrow. *A. placenta*, Herdm. (A. Arct.)
Test not soft; stigmata rather short. *A. lata*, Herdm. (N.W. Eur.)

21 { Body partly incrusted with sand, &c. 36
Body not incrusted with sand 37

36 { Body of a dull green colour, tentacles about 70. *A. plebeia*, Ald. (N.W. Eur. & Med.)
Body not of a green tint, tentacles 10–15. *A. caudata*, Heller. (S. Atl.)

37 { Dorsal lamina with a plain edge.................................... 38
Edge of dorsal lamina not plain 39

38 { Test thick, cartilaginous, opaque, but with no adhering prolongations. *A. quadrata*, Traust. (Med.)
Test rather thin and transparent, with prolongations round the area of attachment.................................... 40

40 { Siphons long, conspicuous; tentacles 60. *A. canaliculata*, Heller. (S. Atl. & Mal.)
Siphons short, wart-like, inconspicuous; tentacles 40–50. *A. prostrata*, Heller. (W. Ind.)

39 { Test very dark coloured... *A. fumigata*, Grube. (Med., N.W. Eur.)
Not of a dark colour.................................... 41

41 { No dorsal tubercle, neural gland opening into atrium. *A. Marioni*, Roule. (Med.)
Dorsal tubercle present, with neural gland opening on it 42

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* The number of tentacles in this species seems variable. *Ascidia incrassata*, Heller, also comes in here, but cannot readily be distinguished from the description.

† Sluiter has just described a new species from the Malay Archipelago under this name "*translucida*." It is, however, quite distinct from the 'Challenger' species, and will require to be renamed.

‡ The *A. Olrikii* of Traustedt (1883), described by him in 1880 under the name of *A. mentula*, seems indistinguishable from this species.

42 { Body 4 or 5 times longer than broad.
A. elongata, Roule. (Med.)
Body not much longer than broad 43

43 { Appearance porcelain-like 44
Not porcelain-like 45

44 { Mantle blue, test cartilaginous and smooth.
A. arachnoidea, Forb. (Med. & N.W. Eur.)
Mantle milk-white, test warty and fibrous.
A. ingeria, Traust. (Med.)

45 { Stigmata 1 large and 2 small, or 4 small in a mesh.
A. kuneides, Sl. (Mal.)
Stigmata not so arranged 46

46 { Test containing a remarkable abundance of branched vessels.
*A. reptans**, Heller. (Med.)
Test with no remarkable development of vessels 47

47 { Dorsal tubercle horseshoe-shaped 48
Dorsal tubercle not horseshoe-shaped 49

49 { Apertures far apart, test thickish, dorsal tubercle rounded.
A. depressiuscula, Heller. (Ind. O.)
Apertures not far apart, test not thick, dorsal tubercle cordate.
A. obliqua†, Ald. (N.W. Eur. & Med.)

48 { Branchial sac with intermediate papillæ 50
Branchial sac with no intermediate papillæ 51

50 { Stigmata short, 4 or 5 in a mesh.
A. depressa, Ald. (N.W. Eur., ? Med.)
Stigmata long, 10 in a mesh.
A. koreana, Traust. (Pac.)

51 { Transverse vessels of 3 sizes 52
Transverse vessels not of 3 sizes 53

52 { Body thrice as long as broad, siphons very long.
A. longitubis, Traust. (W. Ind.)
Body almost as broad as long, siphons not very long.
A. pusilla, Traust. (Med.)

53 { Test rather thick and smooth 54
Test rather thin and wrinkled.
A. malaca, Traust. (Med.)

54 { Colour yellow-grey, tentacles 40–50.
A. interrupta, Heller. (W. Ind.)
Colour milk-white, tentacles 60–70.
A. hygomiana, Traust. (W. Ind.)

The following species of *Ascidia* ‡ are not sufficiently characterized to be put in the table. Some are probably synonyms of well-known species, others may be distinct species, but require further examination and redescription; a few probably do not belong to this genus:—

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* *A. vasculosa*, Herdm. (from Kerguelen), has also numerous vessels in the test, but as only the test is known I have excluded the species.

† *A. pellucida*, Ald. & Hanc., comes close to this, and as no details are known in regard to its internal structure it cannot be separated from *A. obliqua*.

‡ Wagner's *Hyalosoma singulare*, from the White Sea (not *Hyalonema*, as misquoted by Traustedt), seems to me to be merely a young specimen of an *Ascidia*.

Ascidia opalina, MacGill. (N.W. Eur.)
A. orbicularis, O. F. Müll. (N.W. Eur.)
A. complanata, Fabr. (N. Atl.) [Also *A. complanata*, Verr.]
A. vitrea, v. Ben. (N.W. Eur.)
A. cavernosa, Les. (W. Ind.)
A. albeola, Les. (W. Ind.)
A. multiformis, Les. (W. Ind.) [? Molgulidæ.]
A. variabilis, Les. (W. Ind.) [? Cynthiidæ.]
A. ovalis, Les. (?)
A. proboscidea, Les. (W. Ind.)
A. lobifera, Les.* (W. Ind. ?)
A. sydneiensis, Stimps. (Austr.)
A. succida, Stimps. (Austr.)
A. tubifera, Stimps. (China.)
A. calcata, Stimps. (Jap.)
A. rudis †, Ald. (N.W. Eur., Med.)
A. albida, Ald. & Hanc. (N.W. Eur.)
A. elliptica, Ald. & Hanc. (N.W. Eur.)
A. pellucida, Ald. & Hanc. (N.W. Eur.)
A. affinis, Ald. & Hanc. (N.W. Eur.)
A. mollis, Ald. & Hanc. (N.W. Eur.) [Also *A. mollis*, Verr.]
A. Normani, Ald. & Hanc. (N.W. Eur.)
A. plana, Hanc. (N.W. Eur.)
A. Alderi, Hanc. (N.W. Eur.)
A. rubro-tincta, Hanc. (N.W. Eur.)
A. rubicunda, Hanc. (N.W. Eur.)
A. robusta, Hanc. (N.W. Eur.)
A. crassa, Hanc. (N.W. Eur.)
A. inornata, Hanc. (N.W. Eur.)
A. producta, Hanc. (N.W. Eur.)
A. elongata, Ald. & Hanc. (N.W. Eur.)
A. coriacea, Heller. (Med.)
A. verrucosa, Heller. (Med.)
A. rubescens, Heller. (Med.)
A. Suensonii, Traust. (Pac.)
A. capsicum, Costa. (Med.)
Phallusia sulcata, Sav. (Med.)
Ph. clavigera, Otto. (Med.)
Ph. clava, Risso. (Med.)
Ph. holothurioides, Risso. (Med.)
Ph. livida, Risso. (Med.)
Ph. informis, Phil. (Med.)

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* Lesueur also gives a list of 30 species of *Ascidia* (names only), chiefly from the Pacific, none of which are now known (see Journ. Philad. Acad. N. S. vol. iii. p. 8, April 1823).

† This, and a number of the following species of Alder and Hancock, may very likely be good species, but they require redescription.

Through the kindness of Canon Norman I have been enabled to examine the

PACHYCHLÆNA, *Herdman*, 1880.

Body attached, sessile. Branchial aperture 8-lobed, atrial 6-lobed.

Test cartilaginous—or tougher, like india-rubber—very thick, solid and opaque.

Branchial sac longitudinally plicated. Internal longitudinal bars bearing large papillæ at the angles of the meshes. Stigmata straight.

Dorsal lamina in the form of a membrane.

Tentacles simple.

Alimentary canal large, placed on the left side of the branchial sac.

Three species are distinguished from the species of *Ascidia* by their remarkably thick and rigid tests :—

	Dorsal lamina not toothed at the margin. *P. gigantea*, Herdm. (S. Atl.)	
	Dorsal lamina strongly toothed at the margin	1
1	Trans. vessels in branchial sac of two sizes, placed alternately; papillæ not lobed.............................. *P. oblonga*, Herdm. (Austr.)	
	Trans. vessels all one size; papillæ lobed. *P. obesa*, Herdm. (Austr.)	

ABYSSASCIDIA, *Herdman*, 1880.

Body oblong, attached by ventral surface. Branchial aperture with from 8 to 12 lobes, atrial with from 6 to 8 lobes. Apertures far apart.

Test soft, cartilaginous, and transparent.

Mantle thin. Muscle-bands chiefly on one side, irregular and feeble.

Branchial sac very delicate, not longitudinally plicated. Stigmata straight.

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type specimens of some of Alder and Hancock's species which are in his collection, and I hope in time to be able to examine the rest, and perhaps to re-establish or clear up the synonymy of some of the little-known or doubtful forms. Dr. Norman has drawn up for me the following paragraph explanatory of the very meagre published descriptions of the species named by these excellent investigators :—

"It is much to be regretted that an important work on British Tunicata by Messrs. Alder and Hancock, to the preparation of which many years had been devoted, and which at the time of their death was nearly ready for publication, has never been printed. No doubt in some respects the anatomical and physiological results may have been partially at any rate anticipated, but Albany Hancock's researches were always so thorough that it cannot be doubted that they would disclose much of great value, while more detailed specific descriptions of the species briefly described by these authors are absolutely necessary for their positive identification."

Dorsal lamina represented by languets, which may be united by a narrow membrane.

Tentacles simple, filiform.

Viscera on either right or left side of branchial sac. Intestine small, posterior to the œsophagus and stomach, and forming a loop open dorsally. Stomach short and wide.

Gonads forming a round mass situated on the intestinal loop.

This genus is the aberrant member of the subfamily. It is intermediate in its characters between *Ascidia* and *Corella*. It contains the two 'Challenger' species *Abyssascidia Wyvillii*, Herdman, obtained from the south of Australia, at a depth of 2600 fathoms, and *Abyssascidia vasculosa*, Herdman, obtained in the Antarctic south-west of Australia, from a depth of 1950 fathoms. They differ, amongst other points, in the following:—

Apertures 12- and 8-lobed, languets separate, viscera on right side	*A. wyvillii.*
Apertures 8- and 6-lobed, languets united by membrane, viscera on left side	*A. vasculosa.*

Subfamily CIONINÆ, *Roule*, 1884.

Body more or less cylindrical, attached by posterior end.

Test thin and gelatinous, may be modified anteriorly to form a lobe covering the apertures.

Mantle with the musculature mainly longitudinal.

Branchial sac provided with internal longitudinal bars. Stigmata straight.

Dorsal lamina represented by languets.

Alimentary canal on left side of branchial sac, extending posteriorly to it.

I use this subfamily in a somewhat different sense from that proposed by Roule. Keeping *Ciona* as the typical form, I remove *Rhopalæa* to the family Clavelinidæ, and I substitute in its place *Rhodosoma*, which seems to me to have more affinity with *Ciona* than with *Ascidia*.

The two genera are as follows:—

Test modified anteriorly to form an operculum covering the apertures	**Rhodosoma.**
Test not modified	**Ciona.**

RHODOSOMA *, *Ehrenberg*, 1828.

Body cubical or cylindrical, attached, truncated anteriorly.

* This is the *Chevreulius* of Lacaze-Duthiers (1865), the *Schizascus* of Stimpson (1855), and the *Pera* (not *Pera*, of Stimpson) and *Peroides* of Macdonald.

Test folded at the anterior end, so as to form an operculum covering the apertures. The test is hard and cartilaginous.

Branchial sac with the stigmata large and straight.

Dorsal lamina represented by a series of languets.

Alimentary canal on right side of branchial sac.

Gonads forming a network round the median part of the intestine.

There are two distinct species known:—

The dorsal tubercle simple, keyhole-shaped. *R. callense*, Lac.-Duth. (Med.)
The dorsal tubercle horseshoe-shaped ...... *R. pyxis*, Traust. (W. Ind.)

Three other (?) species—*R. seminudum*, Heller (W. Ind.), *R. pellucidum*, Stimps. (China), and *R. papillosum*, Stimps. (China)—require re-examination.

CIONA * (*Savigny*, 1816), *Fleming*, 1828.

Body cylindrical, attached. Apertures anterior, not distant.

Test gelatinous or membranous.

Mantle with the musculature well developed on both sides, forming a few well-marked longitudinal bands.

Branchial sac with the stigmata straight.

Dorsal lamina represented by a series of languets.

Nerve-ganglion and neural gland placed close behind the dorsal tubercle.

Alimentary canal extending behind the branchial sac.

Gonads placed on the left side in the intestinal loop.

	Animals attached in groups by interlocking of villi from posterior end of test .... *C. fascicularis*, Hanc. (N.W. Eur.)	
	Animals separate, solitary	1
1	Body fixed by the whole of left side (*Pleurociona*, Roule). *C. Edwardsi*, Roule. (Med.)	
	Body fixed by posterior end or a part of left side........................	2
2	Transverse vessels all the same size, meshes not divided *C. Flemingi*, Herdm. (N. Atl.)	
	Transverse vessels of two different sizes, meshes divided horizontally...	3
3	Test rough with sharp-pointed projections. *C. aspera*, Herdm. (Jap.)	
	Test smooth, no projections on test	4
4	Fixed by posterior end and short processes of test, siphons unequal ...	5
	Fixed by part of left side, not posterior, siphons equal. *C. Savignii*, Herdm. (Jap., Med.)	
5	Colour brown, mantle vermilion... *C. canina*, O.F.M. (N.W. Eur.)	
	Colour yellow-green or light grey, mantle same. *C. intestinalis*, L. (N.W. Eur., Med., Austr.)	

The following insufficiently characterized species prob

* Including *Pleurociona*, Roule.

belong to *Ciona*, and may, some of them, be synonyms of *C. intestinalis* :—

Ascidia virescens, Bruguière. (N.W. Eur.)
A. corrugata, O. F. Müller. (N.W. Eur.)
A. ocellata, Agassiz. (E. N. Am.)
A. tenella, Stimpson. (E. N. Am.)
A. pulchella, Alder. (N.W. Eur.)
Alina meridionalis, Risso (Med.), may be a *Ciona*, or possibly a Clavelinid.

Family IV. CLAVELINIDÆ, *Forbes*, 1853.

Body attached by the posterior end, and usually by means of a peduncle, to a creeping basal stolon or common stolonial mass from which young ascidiozooids are formed by gemmation.

Test gelatinous, rarely cartilaginous, usually thin and transparent. Apertures circular, very rarely distinctly lobed.

Branchial sac not folded, often without internal longitudinal bars. The bars, if present, have no papillæ. The stigmata are straight.

Dorsal lamina represented by languets.

Tentacles simple, filiform.

Alimentary canal usually extending beyond the branchial sac posteriorly to form an abdomen.

Gonads placed in the intestinal loop. In addition to sexual reproduction, colonies may be formed asexually by gemmation from the stolon.

This family contains 10 genera *, which may be distinguished as follows :—

	Branchial sac with internal longitudinal bars	1
	Branchial sac without internal longitudinal bars	2
1	Body divided into distinct abdomen and thorax	3
	No distinct abdomen present	4
3	Many ascidiozooids united by their posterior parts to form a large colony	**Diazona.**
	Few ascidiozooids united irregularly to form small colony	5
5	Branchial sac minutely plicated	**Rhopalæa.**
	Branchial sac not minutely plicated	**Rhopalopsis.**
4	Blood-vessels in the test	**Sluiteria.**
	No blood-vessels in the test	**Ecteinascidia.**
2	No distinct abdomen present	6
	Abdomen distinct from the thorax	7
6	Branchial sac with about 4 rows of stigmata	**Perophora.**
	With about a dozen rows of stigmata	**Perophoropsis.**

* *Clavelinopsis*, Fewkes, probably does not belong to this family. The single species *C. rubra* seems to be a *Boltenia*.

7 { Body divided into thorax, abdomen, and a well-marked peduncle. **Podoclavella.**
Body not pedunculated apart from the long abdomen 8

8 { Stolons, and posterior end of body, united in a solid basal mass of test .... **Stereoclavella** *.
Stolons distinct, delicate and branched .... **Clavelina.**

DIAZONA †, *Savigny*, 1816.

Colony massive, not pedunculated, consisting of a basal mass of test surrounding the stolons and from which the ascidiozooids project upwards.

Ascidiozooids elongated, divided into thorax and abdomen, and having the latter imbedded in the common basal mass of test. Both branchial and atrial apertures anterior and 6-lobed.

Test solid and thick in the lower part of the colony, thin and delicate on the upper free parts of the ascidiozooids. Contains numerous pigment-cells.

Branchial sac large and well developed, with internal longitudinal bars but no papillæ.

Dorsal lamina represented by triangular languets.

Viscera extending far behind the branchial sac so as to form an abdomen.

Gonads in the intestinal loop.

Three forms of *Diazona* have been described, which may be only varieties of one species, *D. violacea*, Sav.:—

{ With no pigment-lines on thorax. *D. intacta*, Lah. (Med.)
With white pigment-lines 1

1 { With pigmented circles round siphons, and inferior branchial circle. *D. violacea*, Sav. (Med. & N.W. Eur.)
No pigmented circles round siphons, branchial circle superior. *D. hebridica*, F. & G.‡ (N.W. Eur.)

RHOPALÆA §, *Philippi*, 1842.

Body elongated, divided by a constriction into two parts, thorax and abdomen.

Test thick and cartilaginous. Branchial and atrial apertures lobed.

* Also *Pycnoclavella*, Garst.; see p. 603.

† This is the *Syntethys* of Forbes and Goodsir (1853).

‡ Forbes and Goodsir, in their original description, say that the branchial and atrial apertures are not lobed, while Alder states that they are obscurely lobed. In *D. violacea* they are distinctly lobed. Forbes and Goodsir's figure shows pigment around the atrial aperture.

§ The *Rhopalona* of Roule and others. This form has affinities with *Ciona* and the Ascidiidæ, but is, I consider, more closely related to the Clavelinidæ.

Branchial sac minutely plicated; with internal longitudinal bars, which are not papillated.

Tentacles simple.

Heart and pericardium curved into a U-shape.

This genus contains two species:—

Branchial aperture 8-lobed, atrial 6 ...... *R. neapolitana*, Phil. (Med.)
Branchial aperture 6-lobed, atrial 12 ... *R. cerberiana*, Lah. (Med.)

Rhopalopsis, *Herdman*, 1890.

Body elongated, divided into thorax and abdomen.

Test cartilaginous. Apertures not distinctly lobed.

Branchial sac not minutely plicated. Internal longitudinal bars present, but not papillated.

This genus contains the two following species:—

Test thin anteriorly, dark coloured .... *R. fusca*, Herdm. (Mal.)
Test thick all over, light grey .... *R. crassa*, Herdm. (Mal.)

Sluiteria, *Ed. v. Ben.*, 1887.

Body short, not divided into thorax and abdomen, united to the stolon by a short peduncle. Apertures both 7-lobed.

Test containing blood-vessels terminating in conical papillæ.

Branchial sac not minutely plicated. Many rows of stigmata present.

Dorsal lamina in the form of a membrane provided with long marginal processes.

This genus was formed for the reception of the single species *S. rubricollis*, Sluiter, from the island of Billiton in the Malay Archipelago.

Ecteinascidia, *Herdman*, 1880.

Body elongated, usually tapering posteriorly, sometimes with a short peduncle; but not divided into thorax and abdomen.

Test thin and membranous, containing no blood-vessels. Apertures not distinctly lobed.

Mantle thin, musculature consisting of transverse bands.

Branchial sac with internal longitudinal bars, but no papillæ.

Dorsal lamina represented by a series of tentacular languets, which may be connected at their bases by a narrow membrane.

Tentacles simple.

Viscera placed on the left side of the branchial sac, and sometimes projecting slightly beyond it posteriorly.

Gonads placed in the intestinal loop, the spermatic vesicles forming a crescentic curve around the ovary.

This genus contains four species, which may be separated as follows :—

	Tentacles about 40 in number .... *E. diaphanis*, Sluit. (Mal.)	
	Tentacles about 80 in number	1
1	Dorsal languets and connecting-ducts wide and membranous. *E. Moorei*, Herdm. (Med.)	
	Dorsal languets and connecting-ducts narrow and papilliform	2
2	Tentacles of 3 lengths, languets separate. *E. turbinata*, Herdm. (N. Atl.)	
	Tentacles not distinctly of 3 lengths, languets united by a narrow dorsal membrane .... *E. Thurstoni*, Herdm. (Ind. O.)	

Ascidia claviformis, Lesueur* (W. Ind.), probably belongs to this genus, but is not sufficiently characterized.

PEROPHORA (*Lister*, 1834), *Wiegm.*, 1835.

Body short, not divided into thorax and abdomen, attached by a short peduncle to a creeping stolon.

Test thin and transparent. Branchial aperture 6-lobed, atrial 5-lobed, rather distant.

Branchial sac with connecting-ducts which may branch to form imperfect internal longitudinal bars. About 4 rows of stigmata present.

Dorsal lamina more or less of a membrane bearing narrow languets.

Alimentary canal placed on the left side of the branchial sac.

This genus contains 3 or 4 species†, as follows :—

	Ascidiozooids on distinct pedicels which are jointed; some adhering sand on test .... *P. Hutchinsoni*, Macd. (Austr.)	
	Ascidiozooids not on distinct pedicels, no jointing present, no adhering sand	1
1	Body colourless, 40 tentacles of 3 sizes, only papilliform connecting ducts .... *P. Listeri*, Wiegm. (Atl., ? Med.)	
	Body greenish, 20 tentacles of 2 sizes, papilliform connecting-ducts with rudimentary internal longitudinal bars. *P. viridis*, Verr. (E. N. Am.) [?=*P. banyulensis*, Lah. (Med.).]	

PEROPHOROPSIS, *Lahille.*

Body nearly cylindrical, sessile. Branchial aperture 12-lobed, atrial 6-lobed.

* Journ. Acad. N. S. Philadel., April 1823, vol. iii. p. 5.

† Giard has named a species from Roscoff, *P. fragilis*. It has not yet, I believe, been sufficiently described.

Test thin, membranous, transparent.

Branchial sac with no internal longitudinal bars and no connecting-ducts. Numerous (15 or 16) rows of stigmata are present.

Dorsal lamina represented by languets.

Alimentary canal on the left side of the branchial sac.

Gonads forming a network over the intestinal loop.

This genus contains the single species *Perophoropsis Herdmani*, Lahille, from Banyuls (Med.).

PODOCLAVELLA, *Herdman*, 1890.

Body extremely long and narrow, divided into thorax, abdomen, and a well-marked post-abdominal peduncle.

Test moderately thick, cartilaginous.

Branchial sac with no internal longitudinal bars, and no papilliform connecting-ducts.

Viscera extending behind the branchial sac to form a large abdomen.

I have formed this new genus for the reception of Savigny's *Clavelina borealis*, and a new species which will be described in the Catalogue of Tunicata of the Australian Museum which I am now preparing.

Colour light bluish green, tentacles in 2 rows. *P. borealis*, Sav. (Arct.)
Colour purplish, tentacles in 1 row .... *P. meridionalis*, Herdm. (Austr.)

STEREOCLAVELLA*, *Herdman*, 1890.

Body elongated; attached to a basal mass of solid test which is formed by the fusion or thickening of the stolons; divided into thorax and abdomen; apertures circular, not lobed.

Test thin anteriorly, may be thick and cartilaginous posteriorly where it joins and forms the stolonial mass.

Branchial sac, &c., as in *Clavelina*.

I have grouped together under this name those species of *Clavelina* which have the stolons and the posterior ends of the bodies imbedded in a basal mass of test. It may be regarded, along with *Podoclavella*, as being scarcely worthy of generic rank, and I am

* Since this was put in type Garstang has published (May 1891) a description of a new genus, *Pycnoclavella*, which seems very closely allied to *Stereoclavella*. However, it may be a distinct form characterized by the presence of stolonial tubes (vessels) in the free test covering the œsophageal region of the body. It contains the species *P. aurilucens*, Garst., found at Plymouth.

quite willing that both should be placed merely as subgenera of *Clavelina*; but I consider that it is convenient to separate off under a distinct name groups of species which resemble one another, but differ from the rest, in some marked characteristic.

The species of *Stereoclavella* are as follows:—

	Dorsal languets short	*S. oblonga*, Herdm. (Atl.)
	Dorsal languets very large	1
1	Horizontal membranes of the branchial sac wide.	*S. enormis*, Herdm. (S. Atl.)
	Horizontal membranes narrow	*S. australis* *, Herdm. (Austr.)

Clavelina, *Savigny*, 1816.

Body elongated, club-shaped, but with no peduncle beyond the abdomen; attached to a delicate, branched, creeping stolon from which buds are formed; divided into thorax and abdomen.

Test thin, gelatinous, or cartilaginous. Apertures circular, not lobed.

Mantle thin, muscles mainly longitudinal.

Branchial sac without internal longitudinal bars. Stigmata straight, no papilliform connecting-ducts. Horizontal membranes present.

Dorsal lamina represented by languets.

Alimentary canal extending behind the branchial sac to form a well-marked abdomen.

This genus, in the restricted sense in which it is used here, contains only half a dozen species †, some of which, however, are imperfectly characterized.

	Thorax and abdomen of much the same size	1
	Abdomen much longer than thorax	2
1	Only 2 rows of stigmata in branchial sac.	*C. pumilio* ‡, M.-Edw. (N.W. Eur.)
	At least 6 rows of stigmata	3
3	6 to 8 rows of stigmata	*C. nana* §, Lah. (N.W. Eur., Med.)
	12 to 16 rows of stigmata	4
4	With yellow or brown lines of pigment on the thorax.	*C. lepadiformis* §, O. F. M. (N.W. Eur., Med.)
	With white lines of pigment on thorax.	*C. Rissoana*, M.-Edw. (N.W. Eur.)
2	Only 3 or 4 rows of stigmata.	*C. producta*, M.-Edw. (N.W. Eur.)
	About a dozen rows of stigmata.	*C. Savigniana*, M.-Edw. (N.W. Eur.)

* This species will be described in the Catalogue of Tunicata of the Australian Museum.

† Possibly O. F. Müller's *Ascidia gelatina* is a *Clavelina*.

‡ Possibly the young of *C. lepadiformis* or some other species.

§ With several varieties.

Suborder II. *ASCIDIÆ COMPOSITÆ*, Savigny, 1816.

This group contains fixed Ascidians which reproduce by gemmation so as to form colonies in which the ascidiozooids are buried in a common investing mass, and have no separate tests.

The Ascidiæ Compositæ include seven families. It should be remembered that they are in all probability a polyphyletic group, having been derived from several distinct groups of ancestral Simple Ascidians. They are thus a semi-artificial assemblage consisting of those fixed Ascidians which have retained or acquired the power of reproducing by gemmation, so as to form colonies, and in which the ascidiozooids have remained so intimately united that their tests form a common colonial mass.

Family I. BOTRYLLIDÆ, *Giard*, 1872.

Colony usually thin and incrusting, sometimes in the form of thick fleshy masses.

Systems circular, elliptical, or forming branched lines. Common cloacal openings distinct, usually lobed.

Ascidiozooids short and not divided into regions.

Test usually soft, traversed by numerous vessels with large terminal knobs.

Branchial sac large and well developed, internal longitudinal bars present, stigmata numerous.

Dorsal lamina in the form of a plain membrane.

Tentacles simple, not more than 16 in number.

Alimentary canal placed alongside the posterior part of the branchial sac.

Gonads on both sides of the body.

Gemmation lateral, from the bodies of the ascidiozooids; and also stolonial, from the ectodermal processes or vessels in the test.

This family includes five genera, which may be distinguished as follows:—

	Colony stalked. Gonads unpaired, in intestinal loop.	**Symplegma.**
	Colony sessile. Gonads paired, placed laterally	1
1	Systems circular in outline	2
	Systems elongated or branched irregularly	3
2	Colony thin, incrusting	**Botryllus.**
	Colony thick and fleshy	**Polycyclus.**
3	Colony thin, incrusting	**Botrylloides.**
	Colony thick and fleshy	**Sarcobotrylloides.**

SYMPLEGMA, *Herdman*, 1886.

Colony stalked, consisting of several ovate ascidiaria* connected by branched peduncles.

Ascidiozooids moderately large, not much elongated, and not divided into regions.

Test firm, vessels numerous.

Branchial sac large and well developed, provided with internal longitudinal bars.

Dorsal lamina in the form of a plain membrane.

Alimentary canal and *gonads* forming a mass projecting for a short distance only behind the branchial sac.

This genus, which I placed in 1886 in the family Distomidæ on account of the close resemblance of the colony to that of a *Colella*, I now agree with Lahille had better be transferred to the Botryllidæ. The Botryllid affinities, as I pointed out in the original description, are very marked, although *Symplegma* differs more from the other four genera of Botryllidæ than these do from one another.

There is only one known species, *Symplegma viride*, Herdm., from Bermuda.

BOTRYLLUS, *Gærtner & Pallas*, 1774.

Colony thin, incrusting.

Systems circular or stellate.

Ascidiozooids ovate, with their apertures placed far apart.

Test soft and gelatinous, never much thickened.

Branchial sac large, with 3 internal longitudinal bars on each side.

Viscera alongside the branchial sac, at its posterior end.

This genus contains a very large number of species which are very difficult to distinguish. In fact, species do not appear to be at all clearly differentiated; and, to add to the difficulty, many of the descriptions are very imperfect and only take account of external characters which cannot be applied to preserved specimens.

The following is a list of the species of *Botryllus*. In the present state of our knowledge of these forms I feel that it is useless to attempt to distinguish them by brief characters in tabular form. Some of these species have several marked varieties, and most are very variable.

* That part of the colony in which the ascidiozooids are placed.

B. Schlosseri (Pallas), Sav. (N.W. Eur., Med.) Yellow with rust-red dots.
B. Baeri, Grube. (Med.) Colony very thin.
B. sannio, Della Valle. (Med.) Colony thick; violet-blue markings.
B. aurolineatus, Giard. (N.W. Eur., Med.) Yellow lines, 8 tent., asc. 2·2 mm. long.
B. morio, Giard. (N.W. Eur., Med.) Nearly black.
B. gemmeus, Sav. (N.W. Eur., Med.) Violet and yellow.
B. violaceus, H. M.-Edw. (N.W. Eur., Med.) Blue, with white lines.
B. tenuis, Della Valle. (Med.) Tentacles 1–3, vessels blue.
B. minutus, Sav. (N.W. Eur., Med.) Asc. 1 mm., 3–5 in syst.
B. smaragdus, M.-Edw. (N.W. Eur.) Green.
B. pruinosus, Giard. (N.W. Eur.) Green.
B. tapetum, Della Valle. (Med.) Grey, 3–8 in syst., 3 tentacles.
B. calendula, Giard. (N.W. Eur.) Yellow, ascidiozooids 1 mm.
B. marionis, Giard. (N.W. Eur.) Ascidiozooids 2·5 mm., 8–10 in syst.; colour brown with white and carmine.
B. rubigo, Giard. (N.W. Eur.) Brown, with red marks.
B. rubens, Ald. & Hanc. (N.W. Eur.) Yellow and red, thin test.
B. virescens, Ald. & Hanc. (N.W. Eur.) Greenish.
B. castaneus, Ald. & Hanc. (N.W. Eur.) Purple-brown, test very thin.
B. Gouldii, Verr. (E. N. Am.)
B. bivittatus, M.-Edw. (N.W. Eur.)

POLYCYCLUS, *Lamarck*, 1816.

Colony thick and fleshy, convex on surface, often lobed.

Systems circular or stellate in outline.

Ascidiozooids ovate, with the apertures rather distant from one another.

Test gelatinous, but solid and much thickened, vessels present.

Branchial sac large and well developed.

Tentacles from 2 to 16 in number.

Alimentary canal placed alongside the posterior end of the branchial sac.

Gonads placed on both sides of the body near the posterior end.

Leaving out a few doubtful forms and older species with imperfect descriptions and which cannot now be determined with any certainty, the genus contains five species. These may be distinguished as follows:—

	Ascidiozooids at least 3 mm. long	1
	Ascidiozooids not 3 mm. long	2
1	With 2 tentacles, placed laterally .... *P. cyaneus*, v. Dr. (Med.)	
	With more than 2 tentacles	3
3	Ascidiozooids at least 4 mm. long	4
	Ascidiozooids about 3 mm. long. Tentacles 8, 2 large lateral and 6 small .... *P. violaceus*, v. Dr. (Med.)	

4	Tentacles 8, 2 large lateral and 6 small. *P. Vallii* *, Lah. (Med.)	
	Tentacles 6, 2 large lateral and 4 small. *P. Renieri*, Lamk. (Med.)	
2	Tentacles 8, all one size.............. *P. Lamarcki*, Herdm. (N.W. Eur.)	
	Tentacles 16, 8 long and 8 short	5
5	Ascidiozooids yellowish, marked with brown. *P. Jeffreysi*, Herdm. (Med.)	
	Ascidiozooids of a bluish colour ... *P. Savignyi*, Herdm. (N.W. Eur.)	

Botrylloides, *H. Milne-Edw.*, 1842.

Colony thin, incrusting and usually gelatinous.

Systems elliptical or elongated, forming branched and sometimes anastomosing lines.

Ascidiozooids cylindrical, with the apertures placed near one another on the anterior end.

Test soft and gelatinous, never much thickened, penetrated by many vessels.

Branchial sac long and well developed.

Alimentary canal placed alongside the branchial sac at its posterior end.

Gonads placed on both sides of the body near the posterior end.

In this case, as in *Botryllus*, it is useless to attempt to distinguish the species in brief tabular form in our present want of knowledge of the internal structure of so many of them; consequently I give the following list of the known species; some of them are in a very doubtful condition.

B. Leachii, Sav. (N.W. Eur., Med.) Purple, with yellow and white marks.

B. luteum, v. Dr. (Adr.) Green-yellow; tentacles 8, 4 large; ascidiozooids 3 mm. in length

B. purpureum, v. Dr. (Adr.) Tentacles 8, 4 large; ascidiozooids 3 mm.

B. Gascoi, Della Valle. (Med.) Tentacles 4; ascidiozooids 2 mm.

B. Emeryi, Della Valle. (Med.) Tentacles 8, 4 large.

B. rubrum, H. M.-Edw. (N.W. Eur., Med.) Colour yellow to red; 4 tentacles.

B. rosaceus, Grube. (Med., Red S.) Purple-red with white lines.

B. morioniformis, Della Valle. (Med.) Yellow-green; tentacles 8, alternately larger; ascidiozooids 2 mm.

B. albicans, H. M.-Edw. (N.W. Eur., Med.) Pure white.

B. ciliatus, D. Ch. (Med.)

B. tyreum, Herdm. (Mal.)

B. perspicuum, Herdm. (Mal.) And var. *rubicundum*.

B. nigrum, Herdm. (Atl.)

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* With several colour varieties noted by Lahille.

B. fulgurale, Herdm. (N. Atl.)

B. rotifera, H. M.-Edw. (N.W. Eur.) Yellow, with red marks.

B. prostratum, Giard. (N.W. Eur.) Ascidiozooids larger and flatter than in *B. rotifera*.

B. clavelina, Giard. (N.W. Eur.) Perfectly transparent.

B. insigne, Giard. (N.W. Eur.) Dark brown, marked with yellow and violet.

B. sparsa, Alder. (N.W. Eur.)

B. pusilla, Alder. (N.W. Eur.)

B. radiata, Ald. & Hanc. (N.W. Eur.) Yellow.

B. ramulosa, Ald. & Hanc. (N.W. Eur.) Pellucid and cream-colour.

SARCOBOTRYLLOIDES, *von Drasche*, 1883.

Colony thick and fleshy, often lobed.

Systems elliptical or elongated, forming branched and sometimes anastomosing lines.

Ascidiozooids cylindrical, with the apertures placed near one another on the anterior end.

Test gelatinous, rather solid and greatly thickened; many vessels present.

Branchial sac large and well developed.

Tentacles 8 to 16 in number.

Alimentary canal placed alongside the posterior part of the branchial sac.

Gonads placed on both sides of the body near the posterior end.

Six species of this genus are known to me, and may be distinguished as follows:—

	Tentacles 8	1
	Tentacles 16	2
1	Test opaque white .... *S. superbum*, v. Dr. (Med.)	
	Test transparent grey	3
3	Colour red-purple; ascidiozooids 3 mm. long, very close; 16 rows of stigmata .... *S. purpureum*, n. sp. (Austr.)	
	Colour dull slate-grey; ascidiozooids 2 mm. long, not very close; 14 rows of stigmata .... *S. pannosum*, n. sp. (Austr.)	
2	Stomach has cæcum .... *S. anceps*, n. sp. (Austr.)	
	No cæcum present	4
4	Tentacles 8 long and 8 short .... *S. Wyvillii*, Herdm. (N. Atl.)	
	Tentacles 4 long, 4 medium, and 4 short. *S. jacksonianum*, n. sp. (Austr.)	

Family II. DISTOMIDÆ (*Giard*, 1872), *Herdm.*, 1885.

Colony rounded and massive, rarely incrusting, either sessile or supported upon a long or short peduncle.

Systems irregular, inconspicuous or absent.

Ascidiozooids of moderate length, and having the body divided into two regions, thorax and abdomen; they may be provided with long vascular ectodermal appendages.

Test gelatinous or cartilaginous, often thickened at the base to form a peduncle, which may be traversed by large canals containing the vascular appendages of the ascidiozooids. There are sometimes calcareous spicules, which, however, are not stellate.

Branchial sac well developed; no internal longitudinal bars present.

Dorsal lamina represented by a series of languets.

Alimentary canal placed posteriorly to the branchial sac, so as to form an abdomen.

Gonads and heart in the intestinal loop, or alongside it. Spermatic vesicles numerous, vas deferens straight.

The genera in this family may be separated as follows:—

	Colony with a well-marked peduncle	1
	Colony sessile or only shortly pedunculated	2
1	With an incubatory pouch in which embryos develop	**Colella.**
	No incubatory pouch present	3
3	Ascidiozooids completely imbedded in a common test.	**Oxycorynia.**
	Ascidiozooids not completely imbedded in a common test.	**Chondrostachys.**
2	With an incubatory pouch and an atrial languet	**Distaplia.**
	No incubatory pouch present	4
4	Ascidiozooids enclosed by capsules formed of discoid spicules.	**Cystodytes.**
	No spicules present in test	5
5	With an atrial siphon	**Distoma.**
	With a trifid atrial languet	**Heterotrema.**

Colella, *Herdman*, 1885* (*MS.*, 1880).

Colony more or less club-shaped, composed of a peduncle attached at the base, and bearing on its summit a more or less ellipsoidal ascidiarium.

Ascidiozooids imbedded in a common test; usually arranged in lines but not divided into systems. No common cloacal cavities. Body composed of thorax and abdomen, and a long ectodermal vascular process from the posterior end of the latter. Apertures six-lobed, not prominent.

* This genus was fully diagnosed, with *Colella Thomsoni* as the type species, in my thesis for the degree of Doctor of Science, sent in to the University of Edinburgh and accepted by the Science Degrees Committee in March 1880; and was published without material change in the second part of my 'Challenger' Report, printed off in 1885.

Test gelatinous, penetrated by the ectodermal prolongations from the ascidiozooids.

Branchial sac well developed; no internal longitudinal bars present.

Dorsal lamina composed of languets.

Alimentary canal posterior to the branchial sac.

Gonads placed on the left side of the intestinal loop. Testes grape-like in arrangement. Embryos develop in an incubatory pouch which is a large diverticulum from the atrial cavity.

The species of *Colella* may be distinguished as follows :—

	Peduncle branched		1
	Peduncle unbranched		2
1	Lower end of peduncle branched		3
	Upper end of peduncle branched, 3 rows of stigmata, tentacles 5 large and 5 small	*C. plicata*, n. sp. (Austr.)	
3	Peduncle short and wide, tentacles 16, 8 rows of stigmata.	*C. concreta*, Herdm. (A. Arct.)	
	Peduncle long and narrow		4
4	Tentacles 12, all of one size, 4 rows of stigmata.	*C. ramulosa*, Herdm. (S. Pac.)	
	Tentacles of two sizes	*C. tenuicaulis*, n. sp. (Austr.)	
2	Peduncle longer than body		5
	Peduncle not longer than body		6
5	Colour red, tentacles 12	*C. pulchra*, Herdm. (Austr.)	
	Colour bluish, tentacles 8, many rows of stigmata.	*C. Thomsoni*, Herdm. (Mal.)	
	Colour greyish yellow		7
7	Tentacles large, 16; 5 rows of stigmata.	*C. pedunculata*, Q. & G. (Austr., A. Arct.]	
	Tentacles small, 8	*C. Gaimardi*, Herdm. (S. Atl.)	
6	Colony wide at top		8
	Colony narrow at top		9
8	Colour grey	*C. Murrayi*, Herdm. (S. Pac.)	
	Colour with a reddish tinge	do., var. *rubida*, Herdm. (Austr.)	
9	Body not longer than broad, tentacles 12, 4 rows of stigmata.	*C. Quoyi*, Herdm. (A. Arct.)	
	Body longer than broad		10
10	Ascidiozooids less than 2 mm. long, tentacles numerous (16 large and 16 small) and close	*C. elongata*, Herdm. (Austr.)	
	Ascidiozooids more than 5 mm. long, tentacles not numerous.	*C. claviformis*, n. sp. (Austr.)	

Oxycorynia, *von Drasche*, 1882.

Colony club-shaped, pedunculated. The peduncle traversed by the long vascular appendages of the ascidiozooids, from which buds are formed.

Ascidiozooids completely imbedded in the common test; divided into thorax and abdomen, and having long ectodermal appen-

dages. Branchial and atrial apertures circular, the former sometimes 4-lobed.

Test thin and transparent round the ascidiozooids, more solid and opaque in the peduncle.

Branchial sac with numerous rows of stigmata. No internal longitudinal bars.

Tentacles 8, 4 large and 4 small.

Alimentary canal behind the branchial sac. Stomach smooth.

Gonads in the intestinal loop. No incubatory pouch present.

This genus contains the single species *Oxycorynia fascicularis*, von Drasche, from the Caroline Islands.

Chondrostachys, *Macdonald*, 1858.

Colony club-shaped, pedunculated. The peduncle traversed by the long vascular appendages of the ascidiozooids, from which buds are formed.

Ascidiozooids not imbedded in a common test, but freely projecting from the surface of the colony, each covered by its own thin layer of test. Body divided into thorax and abdomen, and having a long ectodermal vascular appendage. Branchial aperture 4-lobed.

Test thin and transparent over the ascidiozooids, thicker and more opaque in the common peduncle.

Branchial sac with no internal longitudinal bars (?).

Alimentary canal behind the branchial sac, forming an abdomen.

Gonads alongside the intestine. No incubatory pouch present.

This genus contains a single species, from Bass Strait, Australia, unnamed by Macdonald.

Distaplia, *Della Valle*, 1881.

Colony in the form of lobed masses or club-shaped knobs.

Systems distinct, each one forming a knob or lobe of the colony.

Ascidiozooids elongated antero-posteriorly, and placed vertically in the colony. Branchial aperture 6-lobed. Atrial aperture provided with a languet.

Test gelatinous, penetrated by ectodermal prolongations from the ascidiozooids.

Branchial sac with 4 rows of long stigmata, crossed by narrow intermediate transverse vessels.

Dorsal lamina represented by a series of short languets.

Alimentary canal posterior to the branchial sac. Stomach ovate, smooth-walled.

Gonads placed on the right side of the intestinal loop. The embryos develop in an incubatory pouch formed as a diverticulum from the atrial cavity. The larvæ are of large size and are gemmiparous.

The four known species of *Distaplia* may be separated thus:—

Colony forming a thick incrusting mass. *D. lubrica*, v. Dr. (Med.)
Colony formed of a number of distinct knobs or club-shaped masses... 1

1 Ascidiozooids and larvæ very large; stomach-wall reticulated. *D. magnilarva*, D. Valle. (Med.)
Ascidiozooids and larvæ of moderate size; stomach-wall smooth 2

2 Knobs of colony with short peduncles or none; colour rose-red. *D. rosea*, D. Valle. (Med. & N.W. Eur.)
Knobs with well-marked peduncles; colour dark violet or purple. *D. Vallii*, Herdm. (Med. & Mal.)

Distoma, *Gærtner*, 1774, *Sav.*, 1816.

Colony massive, sessile or scarcely pedunculated.

Systems absent or imperfect.

Ascidiozooids divided into thorax and abdomen, not enclosed in calcareous capsules, and having both apertures 6-lobed and opening directly on to the surface. Thorax and abdomen often united by a long narrow pedicle.

Test gelatinous, with no spicules.

Branchial sac with from 3 to 20 or more rows of stigmata. No internal longitudinal bars.

Dorsal lamina represented by languets.

Alimentary canal posterior to the branchial sac.

Gonads placed alongside the intestinal loop. No incubatory pouch present for the embryos.

The species of *Distoma* may be separated thus:—

Wall of stomach smooth 1
Stomach-wall not smooth 2

2 Wall of stomach thickened to form a reticulation; 24 rows of stigmata. *D. adriaticum*, v. Dr. (Med.)
Wall of stomach grooved longitudinally; 12 rows of stigmata. *D. cristallinum**, Ren. (Med., N.W. Eur.)

1 With only 3 rows of stigmata in branchial sac 3
With more than 3 rows of stigmata 4

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* *D. vitreum*, Sars, is either this species or closely related to it.

3	Colony of a resinous-brown colour.	*D. mucosum*, v. Dr. (Med.)
	Colony blackish, not sandy	*D. Panceri* *, D. Valle. (Med.)
4	Colony blackish, sandy on surface.	*D. Costæ*, D. Valle. (Med.)
	Colony red	*D. variolosum* †, Gærtn. (N.W. Eur.)

Heterotrema, *Fiedler*, 1889.

Colony massive, branched, attached.

Systems placed in irregularly polygonal areas marked out by grooves.

Test gelatinous, with no spicules.

Ascidiozooids with body separated into thorax and abdomen, and having ectodermal processes. Branchial aperture 6-lobed; atrial not lobed, but with a trifid atrial languet.

Branchial sac well developed, without internal longitudinal bars, with 8–10 rows of stigmata.

Dorsal lamina represented by languets.

Alimentary canal placed behind the branchial sac. Stomach longitudinally folded.

Spermatic vesicles numerous, placed in the posterior part of the abdomen.

This genus, closely allied to *Distoma*, contains the single species *Heterotrema Sarasinorum*, Fiedl., from Ceylon.

Cystodytes, *von Drasche*, 1883 (subgen.), *Herdm.*, 1886.

Colony of irregular form, attached and incrusting, sometimes lobed, and of moderate thickness.

Ascidiozooids surrounded by capsules formed of calcareous discoid spicules. No ectodermal appendages present.

Test cartilaginous, containing calcareous disc-shaped spicules which form a capsule round each ascidiozooid.

Branchial sac small; about 4 rows of stigmata.

Abdomen as large as thorax. Stomach smooth.

The five known species of *Cystodytes* may be distinguished as follows:—

Ascidiozooids arranged in distinct systems	1
Ascidiozooids not distinctly arranged in systems	2

* *D. plumbeum*, D. Valle (Med.), seems to differ from this only in the size and proportions of the ascidiozooids.

† *D. rubrum*, Sav., is close to if not identical with this.

1	Colour yellowish brown	*C. durus*, v. Dr. (Med.)
	Colour whitish and translucent	*C. cretaceus*, v. Dr. (Med.)
2	Colour violet	*C. DelleChiaiæ*, D. Valle. (Med.)
	Colour brownish grey	3
3	Test not much vacuolated	*C. Draschii*, Herdm. (S. Atl.)
	Test very much vacuolated, darker than last.	*C. philippinensis*, Herdm. (Mal.)

Family III. POLYCLINIDÆ, *Giard*, 1872.

Colony usually massive; sometimes incrusting, sometimes lobed or even pedunculated.

Systems of various shapes, sometimes very irregular or absent. Common cloacal apertures usually inconspicuous.

Ascidiozooids always elongated antero-posteriorly, and usually divided into three distinct regions. Branchial aperture 6- or 8-lobed; atrial aperture often with atrial languet.

Test gelatinous or cartilaginous, sometimes rendered stiff by imbedded sand-grains.

Branchial sac usually small and not highly developed. Stigmata usually small. There may be papilliform connecting-ducts but never internal longitudinal bars.

Dorsal lamina represented by a series of languets.

Tentacles small and not numerous.

Alimentary canal extending considerably beyond the branchial sac posteriorly.

Gonads placed behind the intestinal loop in the postabdomen. Testis represented by a number of small spermatic sacs, attached to a large vas deferens.

Gemmation from the postabdomen, which has the heart at its extremity.

This very large family* contains about twenty genera (or subgenera), which may be distinguished briefly as follows :—

Branchial sac with wide meshes and no true stigmata.	**Pharyngodictyon.**
Branchial sac normal	1

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* I cannot follow Lahille in breaking it up into the two families Polyclinidæ and Aplididæ; nor can I employ, as he does, the twisting of the intestinal loop as a primary character in distinguishing the genera; intermediate conditions are found between the typical Polyclinid condition and that found in *Amaroucium*.

1	Branchial sac with papilliform connecting-ducts in its interior.	**Tylobranchion.**
	Branchial sac not papillated *	2
2	Stomach smooth-walled	3
	Stomach-wall thickened	4
3	Horizontal membranes denticulated to form projections between the stigmata	**Glossophorum.**
	No such projections formed	5
5	Intestinal loop simple, U-shaped	**Aplidiopsis.**
	Intestinal loop twisted	6
6	Systems simple	**Polyclinum.**
	Systems compound	**Aurantium.**
4	Atrial aperture on the dorsal edge	7
	Atrial aperture on the anterior end	8
7	Sand-grains imbedded in and incrusting test	**Psammaplidium.**
	Test not containing sand-grains	**Aplidium.**
8	Branchial aperture 8-lobed	9
	Branchial aperture 6-lobed	10
9	Wall of stomach folded or grooved	11
	Wall of stomach areolated or with grooves broken up	12
11	Systems simple	**Circinalium.**
	Systems compound	13
13	Postabdomen slightly pedunculated	**Fragarium** †.
	Postabdomen not at all pedunculated	**Fragaroides** †.
12	Postabdomen separated from abdomen by constriction.	**Parascidia.**
	Postabdomen not separated off by constriction	**Morchellioides.**
10	Wall of stomach folded or grooved	14
	Wall of stomach areolated	15
14	Wall of stomach folded transversely	**Atopogaster.**
	Wall of stomach folded longitudinally	16
16	Postabdomen separated off by a constriction	**Polyclinoides.**
	Postabdomen not separated off by constriction	17
17	Atrial aperture 6-lobed	**Sigillina.**
	Atrial aperture with a languet	**Amaroucium** ‡.
15	Postabdomen separated off by constriction	**Sidnyum.**
	Postabdomen not separated off	18
18	Systems simple	**Synoicum.**
	Systems compound	**Morchellium.**

PHARYNGODICTYON, *Herdman*, 1885.

Colony club-shaped, or consisting of a "head" (or ascidiarium) placed on a short peduncle.

Systems inconspicuous.

* In *Glossophorum* the so-called papillæ are due to a denticulation of the horizontal membranes.

† These two are very closely related.

‡ The subgenus *Morchelliopsis* of Lahille comes in here, but I do not see that it can be separated from *Amaroucium*. The specific name of the single species, "*Morchelliopsis Pleyberianus* Lahille," must, according to the laws of nomenclature, be *punctum*, Giard.

Ascidiozooids very long antero-posteriorly, and distinctly divided into regions.

Test of a firm gelatinous consistence.

Branchial sac formed of a simple meshwork of longitudinal and transverse vessels. No true stigmata present.

Dorsal lamina represented by a series of languets.

Gonads placed in a long postabdomen extending behind the intestinal loop.

This genus was formed for the remarkable deep-sea species *Pharyngodictyon mirabile*, Herdm., trawled in the Southern Ocean at a depth of 1600 fathoms.

TYLOBRANCHION *, *Herdman*, 1885.

Colony large, massive.

Systems inconspicuous.

Ascidiozooids large, elongated antero-posteriorly, and distinctly divided into regions.

Test gelatinous.

Branchial sac large and well developed. Transverse vessels provided with numerous large papilliform connecting-ducts which may bifurcate to form rudimentary internal longitudinal bars.

Dorsal lamina represented by a series of languets.

Alimentary canal large. Stomach-wall folded longitudinally.

Gonads forming a long postabdomen.

This genus includes the single species *Tylobranchion speciosum*, Herdm., from Kerguelen Island.

GLOSSOPHORUM †, *Lahille*, 1886.

Colony subglobular or expanded and lobed, attached, sandy. Systems usually one in each colony, simple.

Ascidiozooids divided into thorax, abdomen, and postabdomen separated by narrow pedicles. Branchial aperture 6-lobed, atrial with a lobed languet.

Test covered with agglutinated sand-grains.

Branchial sac with well-marked horizontal membranes, which are denticulated or crenated so as to have a number of small

* This genus has affinities with *Diazona* and the Clavelinidæ, but is, I think, more closely allied to the Polyclinidæ.

† This genus seems very similar to *Pleurolophium*, Giard, 1874 (Assoc. Franç., Lille).

papilliform projections nearly as numerous as the stigmata. About a dozen rows of stigmata. No internal longitudinal bars.

Dorsal languets present.

Alimentary canal with the intestinal loop twisted. Stomach smooth.

There are two species of *Glossophorum* :—

Colony small, globular; 32 tentacles; atrial languet lobed.	*G. sabulosum*, Giard. (N.W. Eur., Med.)	
Colony large, flattened; 16 tentacles; atrial languet simple.	*G. humile*, Lah. (Med.)	

The *Amaroucium bilaterale* of Giard (N.W. Eur., 1874) probably belongs to this genus.

Aplidiopsis, *Lahille*, 1890.

Colony subglobular, attached, sessile. Systems irregular or indistinct. Branchial aperture 6-lobed, atrial imperfectly lobed.

Ascidiozooids divided into thorax, abdomen, and postabdomen.

Branchial sac with numerous stigmata.

Alimentary canal with no twisting of the intestine. Stomach smooth.

Postabdomen not separated off from abdomen by a constriction.

The following species may be referred to this genus :—

	Stigmata very small	*A. incertus*, Herdm. (Mag.)	
	Stigmata well developed		1
1	Stomach globular	*A. vitreus*, Lah. (Med.)	
	Stomach pyriform		2
2	Stomach placed vertically	*A. minutus*, Herdm. (South. O.)	
	Stomach placed horizontally	*A. pyriformis*, Herdm. (South. O.)	

Aurantium, *Giard*, 1872.

This genus, or subgenus, seems to differ from *Polyclinum* merely in having the systems compound. It contains a single species, *A. aurantium* (=*Polyclinum aurantium*), M.-Edw., which is possibly identical with *Sidnyum turbinatum* of Savigny.

This group is probably scarcely of sufficient importance to warrant its separation from *Polyclinum*.

Polyclinum, *Savigny*, 1816.

Colony massive, usually sessile.

Systems simple or compound, often irregular.

Ascidiozooids elongated, more or less distinctly divided into three regions. Branchial aperture 6-lobed; atrial aperture provided with a languet.

Test gelatinous or cartilaginous, sometimes incrusted with sand.

Branchial sac large and well developed.

Alimentary canal usually long and complicated, often twisted. Stomach smooth-walled.

Postabdomen separated from the abdomen by a constriction, often projecting from one side of the intestinal loop.

Some of the older described species of *Polyclinum* are so imperfectly known that the following table cannot be regarded as quite satisfactory, but it may be of use in roughly distinguishing the species * :—

	Colony incrusted with sand		1
	Colony not sandy		2
1	Not very much sand in test, stigmata small.	*P. molle*, Herdm. (S. Atl.)	
	A good deal of sand in test, stigmata long and narrow.	*P. fungosum*, Herdm. (Austr.)	
2	Postabdomen attached to ventral edge of abdomen.	*P. depressum*, Herdm. (Austr.)	
	Postabdomen attached to posterior end of abdomen		3
3	Colony of a greenish colour		4
	Colour not green, generally grey or violet		5
4	Gelatinous, green	*P. viride*, D. Ch. (Med.)	
	Not gelatinous, olive-green	*P. ficus*, Sav. (N.W. Eur., ? Med.)	
5	Abdomen separated from thorax by a very long pedicle, as long as abdomen	*P. uranium*, Sav. (Red S.)	
	Abdomen separated only by a short pedicle		6
6	Of a whitish or grey colour		7
	Of a violet or purple tint		8
7	Colour whitish	*P. stellatum*, D. Ch. (Med.)	
	Colour grey	*P. vesiculosum*, D. Ch. (Med.)	
8	Of a purple colour	*P. septosum*, D. Ch. (Med.)	
	Of a bluish or violet tint		9
9	With about 18 rows of stigmata	*P. hesperium*, Sav. (Red S.)	
	With 14–16 rows of stigmata		10
10	Abdomen nearly as large as thorax, stigmata small.	*P. isiacum*, Sav. (Red S.)	
	Abdomen much smaller than thorax, stigmata large		11
11	With 14 rows of stigmata	*P. constellatum*, Sav. (Ind. O.)	
	With 15–16 rows of stigmata		12
12	Colour dark violet	*P. saturnium*, Sav. (Red S., Med.)	
	Colour light violet	*P. cythereum*, Sav. (Red S.)	

* *Polyclinum diazonæ*, D. Ch. (Med.), certainly does not belong to this genus—probably not to the family. *P. fuscum*, D. Ch. (Med.), has the branchial aperture 8-lobed, and therefore cannot be a *Polyclinum*.

PSAMMAPLIDIUM, *Herdman*, 1886.

Colony incrusting, massive, or lobed.

Systems inconspicuous.

Ascidiozooids usually small, not much elongated, and not distinctly divided into regions.

Test thick, and greatly strengthened by imbedded and incrusting sand-grains and other foreign bodies, which form a great part of its bulk.

Branchial sac small and not well developed.

Postabdomen usually short.

The species referred to this genus may be separated as follows:—

	Colony broken up into narrow branched and anastomosing strands. *P. retiforme*, Herdm. (A. Arct.)	
	Colony not retiform	1
1	Colony thin and incrusting	2
	Colony massive	3
2	Colour dark brown ... *P. effrenatum*, Herdm. (S. Atl.)	
	Colour stone-grey ... *P. incrustans*, n. sp. (Austr.)	
3	External part of test forming a distinct layer	4
	External layer of test not modified	5
4	Colony formed of Ascidiarium on narrow peduncle. *P. pedunculatum*, n. sp. (Austr.)	
	Colony formed of irregular masses not pedunculated	6
6	Colony not lobed ... *P. flavum*, Herdm. (S. Atl.)	
	Colony lobed	7
7	Central layer of test free from sand. *P. fragile*, n. sp. (Austr.)	
	Sand all through test	8
8	Stigmata much wider than interstigmatic vessels. *P. solidum*, n. sp. (Austr.)	
	Stigmata same width as vessels or narrower. *P. lobatum*, n. sp. (Austr.)	
5	Colony ovate or pyriform	9
	Colony irregularly lobed	10
9	Much imbedded sand; colony quite stiff	11
	Not much sand; colony firm, but not stiff. *P. ovatum*, Herdm. (Austr.)	
11	Shape ovate, colour green-grey, muscles weak, stigmata long. *P. subviride*, Herdm. (S. Atl.)	
	Shape pyriform, colour yellow-grey, muscles strong, stigmata short. *P. pyriformis*, Herdm. (Austr.)	
10	Short cylindrical lobes from common base, stigmata very narrow. *P. exiguum*, Herdm. (S. Atl.)	
	Lobes irregular, stigmata not very narrow	12
12	Stomach globular, smooth-walled ... *P. spongiforme*, Herdm. (Austr.)	
	Stomach quadrate, folded longitudinally. *P. rude*, Herdm.	

Polyclinoides, *von Drasche*, 1883.

Colony forming rounded transparent masses.

Systems irregular.

Test transparent.

Ascidiozooids divided into thorax, abdomen, and postabdomen. Branchial aperture 6-lobed. Atrial aperture placed far back on the dorsal edge and not lobed; anterior to it is an atrial languet.

Branchial sac with 8 rows of stigmata. No internal longitudinal bars and no papillæ.

Alimentary canal not twisted. Stomach with numerous flat longitudinal folds. Anus provided with two large lobes.

Gonads in a moderately long postabdomen, separated from the abdomen by a slight constriction.

This contains the species *Polyclinoides diaphanum*, v. Drasche, from Mauritius.

Aplidium, *Savigny*, 1816.

Colony massive or lobed, not pedunculated.

Systems compound and irregular.

Ascidiozooids not much elongated. Branchial aperture 6-lobed; atrial lobed, or having a more or less rudimentary languet, and placed far back.

Test gelatinous or cartilaginous, rarely sandy.

Branchial sac fairly well developed.

Alimentary canal of moderate size. Stomach-wall folded longitudinally.

Postabdomen usually short.

Those species of the genus which have been sufficiently characterized can be distinguished thus:—

	Atrial aperture distinctly lobed or with a languet	1
	Atrial aperture with no visible lobes or languet	2
1	Atrial aperture 6-lobed	3
	With an atrial languet	4
3	Colony sandy; branchial sac not pigmented. *A. asperum*, v. Dr. (Med.)	
	Colony not sandy; branchial sac pigmented. *A. pellucidum*, v. Dr. (Med.)	
4	Atrial languet bifurcated .... *A. fuscum*, Herdm. (A. Arct.)	
	Atrial languet not bifurcated	5
5	10 grooves on stomach.......... *A. fallax*, Johns. (N.W. Eur.)	
	4 grooves on stomach..........	6
6	Brown pigment-dots on dorsal edge of thorax. *A. tremulum*, Sav. (Red S.)	
	No such pigment-dots	7

7 { Colony greyish; postabdomen short . *A. lobatum*, Sav. (Med., Red S.)
Colony yellowish; postabdomen very long. *A. caliculatum*, Sav. (N.W. Eur.)

2 { Both transverse and longitudinal muscle-bands very strong. *A. crassum*, Herdm. (S. Atl.)
Musculature not powerful 8

8 { Stigmata very minute and irregular 9
Stigmata normal 10

9 { Colour dark grey .... *A. despectum*, Herdm. (N. Atl.)
Colour dark smoke-brown .... *A. fumigatum*, Herdm. (A. Arct. & Mal.)

10 { With very slight grooves on stomach. *A. leucophæum*, Herdm. (A. Arct.)
Grooves of stomach-wall well marked 11

11 { Grooves few, 4 to 6 12
Grooves numerous, 10 or more 13

12 { Colony sandy.......... *A. gibbulosum**, Sav. (Med.)
Not sandy 14

14 { With only 6 rows of stigmata .... *A. griseum*, Lah. (Med.)
With about a dozen rows of stigmata. *A. effusum*, Sav. (Red S.)

13 { Colony somewhat sandy on surface... *A. incrustans*, Herdm. (S. Atl.)
Colony not sandy 15

15 { Branchial sac pigmented .... *A. cæruleum*, Lah. (N.W. Eur.)
Not pigmented .... *A. zostericola*, Giard. (N.W. Eur.)

AMAROUCIUM, *H. Milne-Edwards*, 1841.

Colony massive, sometimes lobed or pedunculated.

Systems usually compound and irregular.

Ascidiozooids elongated. Branchial aperture 6-lobed; atrial usually provided with a long languet, placed close to the branchial aperture.

Test cartilaginous or gelatinous.

Branchial sac moderately developed.

Alimentary canal of moderate size. Stomach-wall folded longitudinally.

Postabdomen usually very long.

The recognizable species of this large genus may be distinguished thus:—

{ Systems simple, regular, and with few ascidiozooids. *A. Nordmanni*, M.-Edw. (N.W. Eur.)
Systems compound, irregular, and with many ascidiozooids 1

1 { Stomach folded longitudinally 2
Stomach simply rayed 3

3 { Colony transparent, colourless.......... *A. crystallinum*, D. Valle. (Med.)
Colony opaque, coloured 4

4 { Colour white .... *A. lacteum*, v. Dr. (Med.)
Colour orange-red .... *A. conicum*, Olivi. (Med.)

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* Possibly this species ought to be referred to *Amaroucium*.

2	Atrial languet trilobed	5
	Atrial languet simple	6
5	Transparent, with orange pigment on anterior end of endostyle.	*A. punctum**, Giard. (N.W. Eur.)
	White colour	*A. albicans*, M.-Edw. (N.W. Eur.)
6	Colony sandy	7
	Colony not sandy	8
7	Few folds, 5, in stomach-wall	*A. subacutum*, v. Dr. (Med.)
	Many folds, 10 or more	9
9	Of a dark-brown colour	*A. fuscum*, v. Dr. (Med.)
	Of a light colour	10
10	Of a greyish-yellow tint, much sand	*A. densum*, Giard. (N.W. Eur.)
	Of a light-brown tint, little sand	*A. commune*, v. Dr. (Med.)
8	Colony on a short peduncle	11
	Not pedunculated	12
11	Colour black	*A. nigrum*, Herdm. (A. Arct.)
	Colour not black	13
13	Stigmata small, short, and inconspicuous	14
	Stigmata moderately long	15
14	Stomach spherical	*A. globosum*, Herdm. (A. Arct.)
	Stomach cylindrical	*A. variabile*, Herdm. (A. Arct.)
15	Colony grey, with yellowish ascidiozooids.	*A. colelloides*, Herdm. (S. Atl.)
	Whole colony of a reddish tint	16
16	Of an orange-red	*A. proliferum*, M.-Edw. (N.W. Eur., Med.)
	Of a pale rose-red	*A. roseum*, D. Valle. (Med.)
12	Colour white	*A. albidum*, Herdm. (Austr.)
	Colour not white	17
17	Ascidiozooids very small, less than 5 mm. long	18
	Ascidiozooids not small, more than 5 mm. long	19
18	Stigmata well developed	*A. lævigatum*, Herdm. (Mag.)
	Stigmata small	20
20	Colony pale liver-coloured, opaque...	*A. hepaticum*, Herdm. (?)
	Colony light grey, transparent	*A. recumbens*, Herdm. (Mag.)
19	Atrial languet long	*A. irregulare*, Herdm. (Mag.)
	Atrial languet short and inconspicuous	21
21	Numerous stigmata in branchial sac, 18–20 rows.	*A. torquatum*, v. Dr. (Med.)
	Comparatively few stigmata, few rows	22
22	Intestinal loop long and narrow	*A. complanatum*, Herdm. (A. Arct.)
	Intestinal loop short	*A. pallidulum*, Herdm. (Mag.)

ATOPOGASTER, *Herdman*, 1885.

Colony massive and usually of large size.

Systems simple or inconspicuous.

Ascidiozooids large or small, always much elongated antero-posteriorly. Branchial aperture 6-lobed.

Test thick, and usually cartilaginous and tough; not incrusted with sand.

* The *Morchelliopsis Pleyberianus* of Lahille.

Branchial sac usually well developed.

Alimentary canal large. Stomach-wall folded transversely.

Postabdomen long.

The species of *Atopogaster* are as follows:—

	Ascidiozooids arranged in distinct circular systems.	*A. gigantea*, Herdm. (Mag.)	
	Systems inconspicuous		1
1	Ascidiozooids large, more than 1 cm. in length		2
	Ascidiozooids small, less than 1 cm. in length		3
2	Colour orange	*A. aurantiaca*, Herdm. (Austr.)	
	Colour light grey	*A. informis*, Herdm. (?)	
3	Colour yellowish grey	*A. elongata*, Herdm. (Mag.)	
	Colour paler, dull whitish grey	*A. elongata*, var. *pallida*. (S. Atl.)	

Sigillina, *Savigny*, 1816.

Colony elongated, pedunculated, attached.

Test gelatinous.

Ascidiozooids very long, divided into thorax, abdomen, and postabdomen. Branchial and atrial apertures both 6-lobed.

Branchial sac very short. No internal longitudinal bars.

Alimentary canal forming an abdomen which is larger than the thorax. Stomach-wall folded longitudinally.

Gonads in the very long slender abdomen, which is prolonged down through the colony and its peduncle.

This contains the single species *Sigillina australis*, Savigny, from the S.E. coast of Australia.

Synoicum (*Phipps*, 1774), *Sav.* 1816.

Colony sessile or pedunculated. Each system forming a separate club-shaped mass; systems simple.

Test semi-cartilaginous, not sandy.

Ascidiozooids divided into thorax, abdomen, and postabdomen. Branchial aperture 6-lobed, and atrial 6-lobed but irregular, the three anterior lobes being large.

Branchial sac long. No internal longitudinal bars and no papillæ. Many rows of stigmata.

Alimentary canal forming an abdomen as large as thorax; intestine not twisted. Stomach-wall areolated.

Gonads in a postabdomen of moderate length, not separated from abdomen by constriction.

This contains the species *Synoicum turgens*, Phipps, from Spitzbergen.

Sidnyum, *Savigny*, 1816.

Colony massive, or formed of a number of lobes, one corresponding to each system.

Systems compound.

Ascidiozooids elongated and distinctly divided into regions. Branchial aperture 6-lobed; atrial aperture not provided with a languet.

Test gelatinous.

Branchial sac well developed.

Alimentary canal forming a narrow loop. Stomach-wall areolated or irregularly thickened.

Postabdomen long, and separated from the abdomen by a constriction.

This contains two species:—

Colony a globular mass, with broad rounded upper surface. *S. pallidum*, Herdm. (A. Arct.)
Colony lobed, each system forming a truncated cone. *S. turbinatum*, Sav. (N.W. Eur.)

Morchellium, *Giard*, 1872.

Colony massive, sessile, or pedunculated.

Systems compound, irregular, and usually inconspicuous.

Ascidiozooids elongated, but not distinctly divided into regions. Branchial aperture 6-lobed.

Test gelatinous or cartilaginous.

Branchial sac large and well developed.

Alimentary canal usually large. Wall of stomach areolated or irregularly thickened.

Postabdomen large, but not distinctly separated from the abdomen.

This contains two species:—

Colony pedunculated .... *M. argus*, M.-Edw. (N.W. Eur.)
Colony sessile .... *M. Giardi*, Herdm. (A. Arct.)

Morchellioides *, *Herdman*, 1885.

Colony massive, sessile.

Systems compound, inconspicuous.

Ascidiozooids elongated, but not distinctly divided into regions. Branchial aperture 8-lobed; atrial aperture anterior.

* This section is very closely related to the next, *Parascidia*.

Test gelatinous, not sandy.

Branchial sac large and well developed.

Alimentary canal large. Wall of stomach areolated or irregularly thickened.

Postabdomen large, but not distinctly separated from the abdomen by any constriction.

Morchellioides contains two species, which may be distinguished as follows:—

With muscle-fibres in the transverse vessels; branchial lobes rounded.	*M. affinis*, Herdm. (A. Arct.)
No muscle-fibres in vessels; branchial lobes pointed.	*M. Alderi*, Herdm. (N.W. Eur.)

Parascidia *, *Milne-Edwards*, 1842.

Colony massive, attached.

Test gelatinous.

Ascidiozooids having thorax, abdomen, and postabdomen. Branchial aperture 8-lobed.

Branchial sac with no internal longitudinal bars and no papillæ.

Alimentary canal with stomach areolated or pseudo-areolated †.

Postabdomen separated from abdomen by a constriction.

This group has had the following 4 species referred to it:—

	Colony fan-shaped, pedunculated, lobed, orange.	*P. flabellata*, Ald. (N.W. Eur.)	
	Colony globular or forming a flattish expansion		1
1	Colony small, globular, pale yellow...	*P. flavum*, M.-Edw. (N.W. Eur.)	
1	Colony large, flat-topped or lobulated		2
2	Amber-coloured	*P. Forbesi*, Ald.‡ (N.W. Eur.)	
2	Pale red	*P. Flemingi*, Ald.‡ (N.W. Eur.)	

Fragarium, *Giard*, 1872.

Colony massive, attached.

Systems compound; large common cloacal aperture with denticulated margin.

Ascidiozooids having thorax, abdomen, and postabdomen. Branchial aperture 8- (may be 6–12-) lobed; atrial anterior.

* Lahille states that this genus was intended by Milne-Edwards to include forms with the stomach-wall longitudinally folded, and that therefore it is synonymous with the genus *Fragarium* of Giard. I believe it will cause less confusion to leave the definitions of these groups as they now are.

† The thickenings being in the form of longitudinal folds broken up into little knob-like or ellipsoidal projections.

‡ These may possibly be one species.

Branchial sac with no internal longitudinal bars.

Tentacles simple, 12, of two sizes placed alternately.

Alimentary canal not twisted. Stomach-wall longitudinally folded.

Postabdomen long, separated off from abdomen by a slight constriction.

There are two species of *Fragarium*:—

{ Colour rose-red, branchial siphon white ...... *F. elegans*, Giard. (N.W. Eur.)
{ Colour yellow-red, branchial siphon colourless. *F. areolatum*, D. Ch. (Med.)

Fragaroides*, *Maurice*, 1888.

Colony rounded, massive, of cartilaginous consistency, having numerous compound systems. External cloacal apertures few.

Ascidiozooids with 8 branchial lobes. Atrial aperture not lobed, but with a moderately large atrial languet. Thorax larger than abdomen. Postabdomen very long, not pedunculated.

Branchial sac large, with about a dozen rows of stigmata.

Dorsal languets wide.

Tentacles 14, 6 large and 6 small alternately, and 2 additional, very small, placed one at each side of the base of the large mediodorsal tentacle.

Stomach with longitudinal folds.

Postabdomen not separated from abdomen by any constriction.

This contains the single species *Fragaroides aurantiacum*, Maurice, from Villefranche-sur-Mer (Med.).

Circinalium, *Giard*, 1872.

Colony polymorphic, sessile.

Systems absent or simple.

Ascidiozooids with thorax, abdomen, and postabdomen. Branchial aperture 8-lobed, atrial anterior.

Branchial sac moderately large, no internal longitudinal bars.

Stomach-wall folded.

Postabdomen very long.

This contains the species *Circinalium concrescens*†, Giard,

* This subgenus is most closely related to *Fragarium*, and probably ought to be united with it.

† According to Lahille, this is the *Sidnyum turbinatum* of Savigny and of Forbes.

from the north coast of France and the Mediterranean, which has several varieties, differing from one another in the degree of concrescence between the ascidiozooids and systems and lobes of the colony.

Unrecognizable Polyclinidæ.

Amaroucium glabrum, Verr. (E. N. Am.)
A. pallidum, Verr. (E. N. Am.)
A. pellucidum, Verr. (E. N. Am.)
A. stellatum, Verr. (E. N. Am.)
A. constellatum, Verr. (E. N. Am.)
A. pomum (?). (N.W. Eur.)
A. papillosum, Ald. (N.W. Eur.)
A. simulans, Giard. (N.W. Eur.)
Aplidium nutans, Johnst. (N.W. Eur.)
Macroclinum crater, Verr. (E. N. Am.)
Polyclinum succineum, Ald. (N.W. Eur.)
P. cerebriforme, Ald. (N.W. Eur.)

Family IV. DIDEMNIDÆ, *Giard*, 1872.

Colony usually flat, thin, and incrusting, rarely thick and massive, never pedunculated.

Systems complicated and irregular, inconspicuous or absent. Common cloacal apertures usually conspicuous.

Ascidiozooids rather small, divided into two regions—thorax and abdomen. Branchial aperture 6-lobed; atrial plain or provided with an atrial languet.

Test gelatinous or cartilaginous, usually containing stellate calcareous spicules. Ectodermal processes well developed, and provided with muscle-fibres so as to form retractor muscles.

Branchial sac small and not well developed. Rows of stigmata few, usually three or four (rarely six).

Alimentary canal united to thorax by a narrow neck. Stomach usually smooth-walled.

Gonads placed alongside the intestinal loop. Ovary very simple; ova large. Male system consisting of a single large testis, around which the first part of the vas deferens is coiled spirally.

Gemmation from the pyloric region; thorax and abdomen of the new ascidiozooid formed from separate buds. Embryonic blastogenesis rudimentary only.

The genera * in this family (which I use in the restricted sense, as not including Diplosomidæ and Cœlocormidæ) may be distinguished as follows:—

	Colony thick and fleshy	1
	Colony thin, incrusting	2
1	Three rows of stigmata	**Didemnum.**
	Four rows of stigmata	**Didemnoides.**
2	Four rows of stigmata	**Leptoclinum.**
	Six rows of stigmata	**Euccelium.**

DIDEMNUM †, *Savigny*, 1816.

Colony usually thick and fleshy, rarely thin and incrusting.

Ascidiozooids with the atrial aperture on the dorsal edge of the thorax, often placed far back. Atrial siphon lobed or simple. No atrial languet present. Branchial aperture 6-lobed.

Test gelatinous or cartilaginous, usually not very hard or stiff. Stellate calcareous spicules are usually present.

Branchial sac with three rows of stigmata.

Tentacles eight in number.

The species may be distinguished as follows:—

	Test containing spicules	1
	Test with no spicules	2
2	Surface deeply cut up by corrugated sulci. *D. tortuosum*, v. Dr. (Med.)	
	Surface not cut up	3
3	Colour yellow, with dark-brown spots. *D. inarmatum*, v. Dr. (Med.)	
	Colour dull grey ... *D. inerme*, Herdm. (N. Atl.)	
1	Branchial sac prolonged beyond third row of stigmata. *D. graphicum*, Lah. (Med.)	
	Branchial sac not prolonged	4
4	Colony white, vas deferens takes 8 turns. *D. niveum*, Giard. (N.W. Eur.)	
	Colony not white	5
5	Colour yellow to brown	6
	Colour blue or greenish or dark grey	7
6	Colour rich dark brown ... *D. Savignii*, Herdm. (? S. Atl.)	
	Colour yellow and orange	8
8	Colour bright yellow, vas deferens takes 12 turns. *D. cereum* ‡, Giard. (N.W. Eur., [Med.)	
	Colour orange ... *D. aurantiacum*, Herdm. (Austr.)	

* *Lissoclinum*, Verrill, containing two species (*L. aureum* and *L. tenerum*) from the east coast of N. America, is not sufficiently described, It will probably come under *Leptoclinum*.

† Including *Tridid emnum* of Della Valle.

‡ According to Lahille, *D. sargassicola*, Giard (with several varieties), is a variety of this species.

7 { Colour grey-green, with transparent surface-layer. *D. bicolor*, v. Dr. (Med.)
Colour not green 9

9 { Colour steel-blue .... *D. lobatum*, Grube. (Med.)
Colour dark grey to black .... *D. fallax*, Lahille. (Med.)

The following species cannot be placed :—

Trididemnum benda, Della Valle. (Med.)
Didemnum Grubei, v. Dr. (Med.)
D. variolosum, Grube. (Med.)
D. roseum (?), Delle Ch. (Med.)

DIDEMNOIDES, *von Drasche*, 1883.

Colony thick and fleshy.

Test containing stellate calcareous spicules.

Branchial sac with 4 rows of stigmata.

This genus, or subgenus, contains the following species :—

{ Colour wine-red; spicules numerous ...... *D. macroophorum* *, v. Dr. (Med., N.W. Eur.)
Colour resinous yellow-brown; spicules few. *D. resinaceum*, v. Dr. (Med.)

LEPTOCLINUM †, *Milne-Edwards*, 1841.

Colony forming a hard, thin, incrusting layer, rarely thick and massive.

Ascidiozooids with the atrial aperture on or near the anterior end of the body, and provided with a long atrial languet.

Test very hard and firm, densely crowded with calcareous spicules.

Branchial sac usually with four rows of stigmata.

This genus contains a very large number of so-called species, of which, however, many may be merely synonyms or varieties, or merely local and seasonal conditions. The descriptions of the majority of these are so imperfect, that it is impossible to do more than give a list, with an indication of any noteworthy character and of the geographical distribution.

Leptoclinum fulgidum, M.-Edw. (N.W. Eur., Med.)
L. coccineum, v. Dr. (Med.)
L. commune, D. Valle. (Med.)
L. cinnabarinum, Grube. (Med.)

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* *Didemnum rubellum*, Grube, may be this species.

† Including *Tetradidemnum* of Della Valle.

Leptoclinum candidum, Sav. (Red S., Med.)
L. Lacazii, Giard. (N.W. Eur.) [Vas deferens has only 2 or 3 turns.]
L. maculatum, M.-Edw. (N.W. Eur., Med.) [Vas def. has 12 turns.]
L. marginatum, v. Dr. (Med.)
L. coriaceum, v. Dr. (Med.)
L. gelatinosum, M.-Edw. (N.W. Eur., Med.)
L. granulosum, v. Dr. (Med.)
L. asperum, M.-Edw. (N.W. Eur., Med.)
L. dentatum, D. Valle. (Med.)
L. exaratum, Grube. (Med.)
L. tridentatum, v. Dr. (Med.)
L. durum, M.-Edw. (N.W. Eur., Med.)
L. perspicuum, Giard. (N.W. Eur.)
L. perforatum, Giard. (N.W. Eur.)
L. tonga, Herdm. (S. Pac.)
L. Moseleyi, Herdm. (Mal.)
L. speciosum, Herdm. (S. Atl.)
L. annectens, Herdm. (S. Atl.)
L. tenue, Herdm. (S. Pac., N. Atl.)
L. propinquum, Herdm. (Mag.)
L. neglectum, Herdm. (?)
L. albidum, Verr. (E. N. Am., Atl.)
L. luteolum, Verr. (E. N. Am.)
L. subflavum, Herdm. (A. Arct.)
L. Jeffreysi, Herdm. (A. Atl.)
L. Carpenteri, Herdm. (? N. Atl.)
L. Thomsoni, Herdm. (? N. Atl.)
L. Edwardsi, Herdm. (S. Atl.)
L. japonicum, Herdm. (Jap.)
L. Jacksoni, Herdm. (Austr.)
L. rubicundum, Herdm. (A. Arct.) [Colour yellow to rust-brown.]
Tetradidemnum gigas, D. Valle. (Med.)
Eucœlium parasiticum, Giard. (N.W. Eur.)

Eucœlium, *Savigny*, 1816.

Colony thin, incrusting; common cloacal apertures visible, slit-like.

Test filled with markedly stellate calcareous spicules.

Mantle thin and transparent.

Ascidiozooids with the branchial aperture circular or imperfectly lobed; atrial small, indistinct.

Branchial sac with 6 rows of stigmata.

Alimentary canal with a small swelling on the intestine behind the stomach.

The only species that with certainty belongs to this genus is

Eucœlium hospitiolum, Sav., from the Red Sea and the Mediterranean; but the following have been placed under *Eucœlium* :—

E. ravum, Grube. (Med.)
E. parasiticum, Giard. (N.W. Eur.) [A *Leptoclinum*.]
E. croceum, Risso. (Med.)
E. flavidum, Risso. (Med.)
E. subgelatinosum, D. Ch. (Med.)
E. roseum, D. Ch. (Med.)

Family V. DIPLOSOMIDÆ, *Giard*, 1871.

Colony forming a thin incrusting layer, rarely thickened, never pedunculated.

Systems irregular, usually inconspicuous. Common cloacal apertures usually visible.

Ascidiozooids divided into two distinct regions, thorax and abdomen.

Test soft and gelatinous, usually transparent, sometimes pigmented, rarely containing calcareous spicules. Vascular ectodermal appendages provided with muscle fibres penetrating the test.

Branchial sac large, with four rows of stigmata.

Dorsal lamina represented by large languets.

Alimentary canal extending behind the branchial sac. Stomach smooth-walled.

Gonads behind the intestinal loop or on its right side. Testis forming more than one mass. Vas deferens not coiled spirally.

Gemmation pyloric. Larva gemmiparous.

There are two distinct genera:—

{ With calcareous spicules in the test .... **Diplosomoides.**
{ With no spicules in the test .... **Diplosoma.**

DIPLOSOMOIDES *, *Herdman*, 1886.

Colony usually thin and incrusting, sometimes only slightly attached.

Test gelatinous, sometimes firm externally, more or less opaque and of a whitish colour. Calcareous stellate spicules present in the superficial layer. Otherwise as *Diplosoma*.

* Lahille has recently used this genus in a new and totally distinct sense, and therefore the species he refers to *Diplosomoides* are not related to my species.

There are two species known to me :—

With a group of spicules on each side of thorax.	*D. pseudoleptoclinum*, v. Dr. (Med.)
With no such thoracic groups of spicules.	*D. molle*, Herdm. (Mal.)

DIPLOSOMA *, *Macdonald*, 1858.

Colony usually thin and incrusting, rarely thick.

Systems irregular. Common cloacal apertures rounded.

Ascidiozooids divided into thorax and abdomen. Branchial aperture usually 6-lobed, atrial a simple aperture.

Test soft, gelatinous, usually transparent, sometimes pigmented, never with calcareous spicules. Containing muscular processes from the ascidiozooids.

Branchial sac large, with four rows of stigmata.

Alimentary canal moderately large. Stomach ellipsoidal and smooth-walled.

Gonads close to the intestinal loop. Vas deferens straight.

Gemmation pyloric. Larva gemmiparous.

The following species (?) can be distinguished in the genus *Diplosoma* :—

	Branchial aperture 6-lobed	1
	Branchial aperture circular, lobes absent or small	2
2	Test pigmented	*D. spongiforme*, Giard. (N.W. Eur. & Med.)
	Test not pigmented	*D. Macdonaldi*, Herdm. (S. Atl.)
1	Colony thin, incrusting	3
	Colony thick, fleshy	4
3	Larva forms 2 ascidiozooids	*D. Rayneri*, Macdon. (Austr.)
	Larva forms 3 ascidiozooids	*D. crystallinum*, Giard. (N.W. Eur. & Med.)
4	Colour grey or dark green	*D. chamæleon*, v. Dr. (Med.)
	Colour yellow-brown	*D. carnosum*, v. Dr. (Med.)

The following names have also been used for forms coming under this genus, but are either synonyms of some of the above or are so imperfectly known that they cannot be placed :—

D. gelatinosum, M.-Edw. (N.W. Eur.)
D. Listerianum, Della Valle. (Med.)
D. Koehlerianum, Lahille. (N.W. Eur.)
D. punctatum, Forb. (N.W. Eur.)
D. zosterarum, Jourdain. (N.W. Eur.)
D. gyrosum, Grube. (Med.)
D. Listeri, Lahille. (N.W. Eur.)

* Including *Astellium*, Giard; *Brevistellium*, Jourdain; *Pseudodidemnum*, Giard.

Family VI. CŒLOCORMIDÆ, *Herdman*, 1886.

Colony massive, deeply concave on the upper surface, not attached.

Ascidiozooids large, scattered all over the surface. Branchial apertures 5-lobed.

Test soft and gelatinous. Test-cells numerous. Calcareous spicules present in the outer layer of the colony.

Branchial sac large and well developed.

Dorsal lamina represented by a series of languets.

Alimentary canal extending beyond the branchial sac posteriorly, but not forming a distinct abdomen. Stomach smooth-walled.

Gonads hermaphrodite in the adult ascidiozooid. Testis composed of a number of pyriform vesicles, which join a spirally coiled vas deferens.

This family contains the single genus *Cœlocormus*.

CŒLOCORMUS, *Herdman*, 1886.

Colony massive, but not attached; deeply concave on the upper surface, so as to contain a large central cavity.

Ascidiozooids large, not distinctly divided into regions; branchial aperture 5-lobed.

Test soft and gelatinous. Test-cells numerous and large. No bladder-cells. Calcareous spicules present in the superficial layer.

Branchial sac large. Stigmata very long and narrow.

Dorsal lamina represented by a series of long triangular languets.

Tentacles well developed.

Alimentary canal extending beyond the branchial sac posteriorly, but not forming a distinct abdomen. Stomach smooth-walled.

Gonads not large. Ovary only present in the adult ascidiozooid. Testis formed of a number of spermatic vesicles. Vas deferens spirally coiled.

One species, *Cœlocormus Huxleyi*, Herdm., from the S. Atlantic at a depth of 600 fathoms.

Family VII. POLYSTYELIDÆ, *Herdman*, 1886.

Colony massive or incrusting, sessile, rarely pedunculated, or formed of small masses connected by stolons. No common cloacal cavities present.

Ascidiozooids large and usually short-bodied, rarely with a distinct abdomen. Both apertures 4-lobed, and opening directly to the exterior.

Test firm and cartilaginous. Matrix generally fibrillated, test-cells small and inconspicuous, bladder-cells rarely or never present. Vessels abundant, branched, and provided with distinct terminal bulbs.

Branchial sac large and well developed. Folds sometimes present. Internal longitudinal bars strong and fairly numerous.

Dorsal lamina in the form of a plain membrane.

Tentacles numerous, simple.

Alimentary canal usually placed alongside the branchial sac, rarely extending beyond it posteriorly.

Gonads in the form of polycarps attached to, or imbedded in, the mantle, and projecting into the peribranchial cavity.

Gemmation effected by means of the vascular prolongations from the ascidiozooids into the common test (?).

The genera which have been referred to this family may be distinguished as follows:—

	Ascidiozooids projecting above surface of colony	1
	Ascidiozooids completely embedded in common test	2
1	Abdomen as long as the thorax	**Thylacium.**
	No abdomen present	**Polystyela.**
2	Colony formed of small masses united by stolons.	**Chorizocormus.**
	Colony not broken up into masses and stolons	3
3	Colony thick and massive	4
	Colony thin and incrusting	**Synstyela.**
4	Test incrusted with sand	**Oculinaria** *.
	Test not (or very slightly) incrusted with sand	**Goodsiria.**

THYLACIUM, *Carus*, 1850.

Colony formed of individuals projecting from a common fleshy base.

* This genus is only imperfectly known. The description is insufficient.

Ascidiozooid having the body divided into thorax and abdomen. Branchial and atrial apertures 4-lobed.

Two species have been briefly described, but I am unable at present to find any character which will separate them:—*T. Sylvani*, Carus (N.W. Eur.); *T. Normani*, Alder (N.W. Eur.).

POLYSTYELA *, *Giard*, 1874.

Colony consisting of a basal part from which the ascidiozooids project.

Ascidiozooids not divided into thorax and abdomen (?).

Only one species is known, *Polystycla Lemirri*, Giard, from the coast of France.

CHORIZOCORMUS, *Herdman*, 1886.

Colony consisting of a number of distinct masses of small size united by irregular branched stolons.

Ascidiozooids placed either singly or in small groups in the test. When more than one are present, they do not project above the general level. The body is not divided into thorax and abdomen.

Test relatively small in amount, slightly incrusted with sand. Test-cells few, and bladder-cells absent. Vessels present in the test and stolons.

Branchial sac well developed. Rudimentary folds present. Internal longitudinal bars strong.

Dorsal lamina in the form of a plain narrow membrane.

Tentacles well developed.

Alimentary canal not prolonged behind the branchial sac.

Gonads in the form of polycarps.

Only one species, *Chorizocormus reticulatus*, Herdm., has been described, but I have examined three other new species from Australia, so I include them in the following table:—

	With rudimentary folds in the branchial sac. *C. reticulatus*, Herdm. (A. Arct.)	
	With no rudimentary folds	1
1	With more than 20 atrial tentacles. *C. Sydneyensis*, n. sp. (Austr.)	
	Atrial tentacles not more than 20	2
2	With 7 rows of stigmata, and 16 branchial tentacles. *C. leucophæus*, n. sp. (Austr.)	
	With 10 rows of stigmata, and 10 branchial tentacles. *C. subfuscus*, n. sp. (Austr.)	

* Possibly not distinct from *Thylacium*.

SYNSTYELA, *Giard*, 1874.

Colony thin and incrusting.

Ascidiozooids large and closely placed, completely imbedded in the common test. Body not divided into thorax and abdomen.

Test relatively small in amount. Matrix sometimes fibrillated; test-cells small; bladder-cells absent; vessels present.

Branchial sac well developed. Rudimentary folds present. Internal longitudinal bars well marked.

Dorsal lamina in the form of a plain membrane.

Tentacles well developed.

Alimentary canal not prolonged behind the branchial sac. Stomach folded longitudinally.

Gonads in the form of polycarps attached to the mantle.

Two species of *Synstyela* are known :—

Flesh-colour, marked with red.........*S. variegata**, Ald. (N.W. Eur.)
Light grey, with bluish and pink tints. *S. incrustans*, Herdm. (Mag. & Mal.)

GOODSIRIA, *Cunningham*, 1871.

Colony massive, sessile or pedunculated, not incrusted with sand.

Ascidiozooids large and ovate in shape, completely imbedded in the common test; not divided into thorax and abdomen. Apertures 4-lobed, both on the anterior end.

Test solid, cartilaginous, not sandy. Matrix delicately fibrillated. Vessels present.

Branchial sac well developed; folds present, rudimentary, or absent; internal longitudinal bars always present.

Dorsal lamina in the form of a plain membrane.

Alimentary canal not prolonged behind the branchial sac. Stomach folded longitudinally.

Gonads in the form of polycarps.

The species of *Goodsiria* may be distinguished thus :—

Test somewhat sandy; ascidiozooids elongated. *G. lapidosa*, n. sp. (Austr.)
Test not sandy; ascidiozooids rounded 1

* Possibly Giard's *Synstyela* from the French coast may be distinct from this British species.

1	Branchial sac folded; colony discoid. *G. placenta*, Herdm. (S. Atl.)	
	Branchial sac not folded; colony not discoid	2
2	Colony rounded or pyriform, pedunculated. *G. pedunculata*, Herdm. (S. Atl., [Mag.)	
	Colony elongated or irregular, sessile. *G. coccinea*, Cunn. (Mag.)	

Oculinaria, *Gray*, 1868.

Colony massive, erect, elongated.

Test solid, containing sand-grains.

Ascidiozooids completely imbedded in the test.

This imperfectly described genus contains a single species, *Oculinaria australis*, Gray, from the western coast of Australia.

Suborder III. *ASCIDIÆ LUCIÆ*, Sav., 1816.
(Asc. Salpiformes, *Auct.*).

This group contains free-swimming pelagic Ascidians which reproduce by gemmation so as to produce colonies having the form of a hollow cylinder closed at one end. The ascidiozooids forming the colony are embedded in the common test in such a manner that the branchial apertures all open on the outer surface, and the atrial apertures on the inner surface next to the central cavity of the colony. The first four ascidiozooids are produced by gemmation from a rudimentary larva (the cyathozooid) developed sexually.

The Ascidiæ Luciæ include a single family, the Pyrosomidæ, containing one well-marked genus, *Pyrosoma*.

Family PYROSOMIDÆ, *T. R. Jones*, 1848.

Colony free-swimming, and having the form of a hollow cylinder closed at one end.

Systems—only one present, the terminal aperture of the colony being the common cloacal opening.

Ascidiozooids elongated antero-posteriorly, and placed in a single layer with their branchial apertures opening on the surface of the colony, and their atrial apertures into the axial tube or common cloaca. Body of ascidiozooid not divided externally into regions. Apertures not lobed.

Test gelatinous and transparent, containing no spicules, but many small cells.

Branchial sac well developed, not folded. Consisting of

numerous transverse vessels separated by narrow slits (the stigmata) and numerous internal longitudinal bars.

Tentacles present; simple.

Dorsal lamina in the form of languets.

Alimentary canal placed posteriorly to the branchial sac.

Gonads situated in the wall of the peribranchial cavity, posterior to the branchial sac. The embryo becomes a rudimentary larva (the cyathozooid), which gives rise to the first ascidiozooids of the colony.

Gemmation takes place from a ventral and posteriorly-placed stolon.

This family contains the single genus *Pyrosoma*, which may be characterized as follows:—

PYROSOMA, *Péron*, 1804.

Colony free-swimming, and having the form of a cylinder with a large axial cavity closed at one end and open at the other.

Systems—only one present, the terminal aperture of the colony being the single common cloacal opening, and the axial cavity the common cloaca.

Ascidiozooids elongated antero-posteriorly, and placed in a single layer with their anterior ends external and their posterior ends internal. Branchial apertures anterior, opening on the surface of the colony. Atrial apertures posterior, opening into the centrally-placed common cloaca. Body not divided externally into thorax and abdomen. Apertures not lobed.

Test gelatinous and transparent, containing numerous stellate branched cells.

Branchial sac well developed, not folded, and not extending to the posterior end of the body. Vessels of two kinds—transverse vessels which are numerous and closely placed, leaving elongated slits between, which are directed transversely to the antero-posterior axis of the body; and longitudinal vessels, which are not quite so numerous, and cross the transverse vessels so as to form small quadrangular meshes.

Tentacles simple, one ventrally placed larger than the rest.

Dorsal lamina represented by a series of eight or more tapering languets.

Dorsal tubercle with a simple aperture.

Alimentary canal short and simple, placed posteriorly to the branchial sac.

Gonads hermaphrodite, placed posteriorly to the branchial sac, in diverticula of the peribranchial cavity.

Gemmation from a ventrally-placed stolon formed at the posterior end of the endostyle.

The following is a scheme of the known species of *Pyrosoma*. *P. atlanticum* and *P. giganteum* are, however, such closely related forms, that a number of characters have to be taken into account in distinguishing between them. I know of no one good character by which these two species can be separated:—

{ Ascidiozooids arranged in regular verticils. *P. elegans*, Les. (Atl., Med.)
{ Ascidiozooids arranged irregularly 1

1 { Surface of the colony provided with short sharp spines only. *P. spinosum*, Herdm. (Atl.)
{ Surface of the colony provided with large processes of the test 2

2 { Colony conical, processes of test subulate or conical. *P. atlanticum*, Péron. (Atl.)
{ Colony cylindrical, processes of test flattened and lanceolate at their free ends .... *P. giganteum* *, Les. (Atl., Med., A. Arct., Mal.)

Order II. THALIACEA (*Sav.*), *v. d. Hoeven.*

The Thaliacea are free-swimming pelagic forms, which may be either simple or compound, and, in the adult, are never provided with a tail or a notochord.

The test is permanent, and may be either well developed or very slight.

The musculature of the mantle is in the form of more or less complete circular bands, by the contraction of which locomotion is effected.

The branchial sac has either two large or many small apertures (stigmata), leading to a single peribranchial cavity which communicates with the exterior by the atrial aperture.

The anus opens into the peribranchial cavity.

Alternation of generations occurs in the life-history, and may be complicated by polymorphism.

This order includes all the pelagic Tunicata with the exception of *Pyrosoma* and the Appendiculariidæ. It seems a natural

* It must be remembered that *P. giganteum* is *not* the largest species. *P. spinosum*, discovered during the 'Challenger' Expedition, is many times larger than Lesueur's species.

well-defined group, characterized amongst the free-swimming forms by the absence of a tail and a notochord in the adult, and by the occurrence of alternation of generations in the life-history. Temporary colonies may be formed at one stage in the life-history, but they never increase in size by gemmation from the ascidiozooids, which eventually separate from one another. This, along with the alternation of generations, distinguishes the Thaliacea from the Ascidiæ Luciæ Salpiformes), and the absence of a tail and notochord separates them from the Larvacea.

The Thaliacea may be divided into two groups, the Cyclomyaria and the Hemimyaria.

Suborder I. *CYCLOMYARIA* (Krohn), Uljanin, 1884.

Free-swimming pelagic forms which exhibit alternation of generations in their life-history, but never form permanent colonies.

The body is cask-shaped, with the branchial and atrial apertures at the opposite ends. The test is more or less well-developed.

The mantle has its musculature in the form of circular bands surrounding the body.

The branchial sac is fairly large, occupying the anterior half or more of the body. It has distinct walls, and the small slit-like stigmata are usually present in its posterior part only. The peribranchial cavity is mainly posterior to the branchial sac.

The alimentary canal is placed close to the posterior end of the branchial sac.

Hermaphrodite reproductive organs are placed ventrally near the intestine.

The sexual generation in the life-history is always polymorphic.

This suborder contains a single family only.

Family DOLIOLIDÆ, *Keferstein*, 1862.

Body free, more or less barrel-shaped; branchial and atrial apertures terminal and lobed.

Test rather slightly developed.

Mantle containing transverse muscle-bands, which form hoops surrounding the body.

Branchial sac well developed. Stigmata not numerous, generally placed far back.

Dorsal lamina and *tentacles* absent.

Alimentary canal at the posterior end of the branchial sac.

Gonads hermaphrodite.

Gemmation takes place.

Life-history complicated by alternation of generations and polymorphism.

This family contains two genera, which may be distinguished as follows :—

All the muscles in the form of encircling hoops .... **Doliolum.**
The musculature reduced to 2 hoops at each end and two lateral S-shaped bands .... **Anchinia.**

DOLIOLUM, *Quoy and Gaimard*, 1835.

Body always more or less barrel-shaped, not attached, and never forming a colony. Branchial aperture at the anterior end, atrial at the posterior, both surrounded by lobes.

Test very thin, containing no test-cells.

Mantle containing well-developed, transversely arranged muscle-bands, which in the fully developed sexual animal are always eight in number. They surround the body like hoops.

Branchial sac usually of moderate size, occupying the anterior half or three-quarters of the body. Its wall contains transverse and fine longitudinal vessels, separated by stigmata, but no internal longitudinal bars, and it is never folded. The stigmata are placed transversely, and vary in number from five to fifty or more on each side of the sac.

Dorsal lamina and *tentacles* absent.

Nerve-ganglion placed in the median dorsal line, a little anterior to the middle of the body, and between the third and fourth muscle-bands.

Dorsal tubercle placed some distance in front of the nerve-ganglion, and surrounded by the spirally-coiled dorsal ends of the peripharyngeal bands.

Alimentary canal placed ventrally, behind the branchial sac.

Gonads ventral, opening into the peribranchial cavity near to the anus.

A tailed larva is formed, which develops into an asexual form, the blastozooid, the buds from which are polymorphic, giving rise to (*a*) nutritive forms, the gastrozooids; (*b*) foster-forms, the phorozooids; and (*c*) reproductive forms, the gonozooids.

Nine species of *Doliolum* are known, which may be distinguished as follows :—

	Branchial sac with only a few stigmata at its posterior end, forming a straight line	1
	Branchial sac with numerous stigmata extending along the greater part of its length, and forming a curved line	2
1	Only 5 pairs of stigmata.............. *D. rarum*, Grobben. (Med.)	
	At least 10 pairs of stigmata	3
3	10–12 pairs of stigmata .... *D. Mülleri*, Kr. (Med.)	
	25 pairs of stigmata .... *D. Krohni*, Herdm. (S. Pac.)	
2	Stigmata starting dorsally near the 1st muscle-band	4
	No stigmata reaching to the 1st muscle-band dorsally........	5
4	Stigmata reaching to the 1st muscle-band ventrally. [Med.) *D. Ehrenbergi*, Kr. (S. Pac., Atl.,	
	No stigmata in front of the 3rd muscle-band ventrally. *D. affine*, Herdm. (Pac.)	
5	Stigmata starting dorsally about the 2nd muscle-band........	6
	Stigmata starting dorsally behind the 3rd muscle-band	7
6	Stigmata reaching back to the 5th muscle-band. *D. Challengeri*, Herdm. (Pac.)	
	Stigmata reaching back to the 6th muscle-band. [& Atl.) *D. denticulatum*, Q. & G. (S. Pac.	
7	Stigmata reaching only to the 5th muscle-band ventrally. *D. Gegenbauri*, Ulj. (Austr., Med.)	
	Stigmata reaching nearly to the 4th muscle-band ventrally. *D. tritonis*, Herdm. (N. Atl.)	

ANCHINIA* (*Eschscholtz*, 1835), *C. Vogt*.

Body rounded, somewhat elongated dorso-ventrally, not attached, and not forming a colony. Branchial aperture anterior, atrial posterior, both lobed.

Test well developed, containing branched test-cells.

Mantle having only 2 anterior and 2 posterior ring-like muscle-bands, and an S-shaped band on each side in the middle.

Branchial sac having only an oblique row of stigmata at its posterior end.

Alimentary canal forming a U-shaped loop.

Gonads placed on the right side of the body.

The life-history, so far as is known, is similar to that of *Doliolum*, but the three forms of the polymorphic sexual generation do not occur together on one stolon or outgrowth, but are produced successively.

There is only one species known, *Anchinia rubra*, Vogt, from the Mediterranean.

* The *Doliopsis* of C. Vogt.

Suborder II. *HEMIMYARIA*, Herdman, 1888.

Free-swimming pelagic forms which exhibit alternation of generations in their life-history, and in the sexual condition form temporary colonies.

The body is more or less fusiform, with the long axis antero-posterior, and the branchial and atrial apertures nearly terminal.

The test is well developed.

The musculature of the mantle is in the form of a series of transversely-running bands, which do not form complete and independent rings, as in the Cyclomyaria. The branchial and peribranchial cavities form a continuous space in the interior of the body, opening externally by the branchial and atrial apertures, and traversed obliquely from the dorsal and anterior end to the ventral and posterior by a long narrow vascular band which represents the dorsal lamina, the dorsal blood-vessel, and the neighbouring part of the dorsal edge of the branchial sac of an ordinary Ascidian.

The alimentary canal is placed ventrally. It may be either stretched out, so as to extend for some distance anteriorly, or, as is more usual, be concentrated to form, along with the reproductive organs, a rounded opaque mass near the posterior end of the body, known as the visceral mass or "nucleus."

The embryonic development is direct, no tailed larva being formed.

This suborder includes two very distinct families, the Salpidæ, which contains the typical members of the group, and the Octacnemidæ, including a single very remarkable form (*Octacnemus bythius*, Moseley), which in some respects does not conform with the characters given above.

Family I. SALPIDÆ, *Forbes*, 1853.

Body not attached, elongated; branchial and atrial apertures at the opposite ends.

Test well developed, gelatinous or cartilaginous.

Mantle with well-marked muscle-bands, which, however, do not form complete rings, but are wanting ventrally.

Branchial and *peribranchial cavities* forming a large central space opening to the exterior at both ends. Side walls of branchial sac not developed. At most only a few imperfect or rudimentary stigmata found along the dorsal edge.

Dorsal lamina in the form of a vascular ciliated band traversing the central cavity obliquely.

Alimentary canal usually forming a small coiled mass placed posteriorly and ventrally.

Gonads hermaphrodite, but ova and spermatozoa not mature together.

Reproduction also takes place by gemmation, and alternation of generations occurs in the life-history.

The embryo develops in an incubatory pouch. No tailed larva is formed.

This family includes two very distinct groups of species usually recognized as the genera *Salpa* and *Cyclosalpa*; but Lahille has recently broken the former up into four sections or subgenera, and I believe it will be convenient to follow that course.

	Alimentary canal extended, no "nucleus," "chains" circular.	**Cyclosalpa.**
	Alimentary canal coiled to form a "nucleus," "chains" ribbon-like ...	1
1	Several embryos formed at a time	**Iasis.**
	One embryo only at a time	2
2	The embryo covered	**Salpa.**
	The embryo exposed...	3
3	The dorsal lamina or "gill" having only ciliated bands......	**Thalia.**
	The "gill" having rudimentary stigmata	**Pegea.**

CYCLOSALPA, *Blainville*, 1827.

Alimentary canal running antero-posteriorly, and not coiled up to form a "nucleus."

Gemmation results in the formation of a chain of aggregated forms attached together in a circle.

In other particulars like *Salpa*.

This genus contains the following three species:—

	With linear pigmented bands on dorsal edge.	*C. pinnata*, Forsk. (Atl., Pac., Med.)
	With no such bands	1
1	Aggregated form has atrial aperture terminal, posterior. Solitary form with no longitudinal muscles	*C. affinis*, Cham. (Atl., Pac., Med.)
	Aggregated form has atrial aperture dorsal. Solitary form with four longitudinal muscles	*C. dolichosoma-virgula*, Tod.-Vogt. (Med.)

SALPA, *Forskål*, 1775.

Body not attached, elongated, with the apertures at the opposite ends.

Test gelatinous or cartilaginous; transparent.

Mantle with muscle-bands which are more or less incomplete ventrally.

Branchial sac opening freely into the peribranchial cavity; no lateral walls; at most some rudimentary stigmata along dorsal edge.

Dorsal lamina in the form of a vascular band marking the junction of branchial and atrial sacs.

Alimentary canal coiled up to form a small opaque mass placed posteriorly and ventrally, and usually known as the "nucleus."

Chain of aggregated forms in the shape of an elongated ribbon-like band.

One embryo developed at a time, and covered.

This genus has had a number of species referred to it, amongst which the following are sufficiently known to be distinguished:—

	Aggregate forms with only 4 transverse muscle-bands. *S. punctata*, Forsk. (Atl., Med.)	
	Aggregate forms with 5 or 6 muscle-bands	1
1	Aggregate forms with 5 muscle-bands. *S. cylindrica*, Cuv. (Atl., Pac., A. Arct.)	
	Aggregate forms with 6 muscle-bands	2
2	Descending branches of 4th and 5th muscles approximated on each side. *S. runcinata-fusiformis*, Cham.-Cuv. (Atl., Med., Pac., I. O., Mal., A. Arct.)	
	Descending branches of 4th and 5th muscles not approximated. *S. africana-maxima* *, Forsk. (Atl., Ind. O., Med., A. Arct.)	

The solitary form of *S. runcinata-fusiformis* is easily distinguished by the short spinose projections from the posterior end; while *S. cylindrica* and *S. africana-maxima* (which have no such processes) differ from one another in their muscles, those of the latter species being all parallel, while in *S. cylindrica* the four anterior approximate dorsally.

THALIA, *Blumenbach*, 1810.

Branchial sac having only ciliated bands along its dorsal edge.

Alimentary canal closely coiled up to form a "nucleus."

Gemmation results in a ribbon-like band of aggregated forms.

Single embryo develops at a time. It is not covered.

In other particulars like *Salpa*.

This section includes only the species *Thalia democratica-mucronata* †, Forsk. (Atl., Pac., Ind. O., Med., Mal., Austr.), and the variety *flagellifera*, Traust. (Atl. and Ind. O.), distinguished by the very long tapering processes at the posterior end of the body in the solitary form.

* *Salpa mollis*, Herdm. (S. Pac.), is probably allied to this species, but cannot be placed with certainty.

† *Salpa nitida*, Herdm. (Pac.), is probably closely related to this species.

Pegea, *Savigny*, 1816.

Branchial sac having rudimentary stigmata on its dorsal edge, alongside the dorsal lamina.

Alimentary canal coiled up to form a "nucleus."

Gemmation results in a ribbon-like band of aggregated forms.

Single embryo develops at a time. It is not covered.

In other particulars like *Salpa*.

This section contains the single species *Pegea scutigera-confœderata* *, Cuv.-Forsk. (Atl., Pac., Ind. O., Med.).

Iasis† (*Savigny*, 1816), *Lahille*, 1890.

Alimentary canal closely coiled up to form a "nucleus."

Gemmation results in a ribbon-like band of aggregated forms.

Embryos 2 or 3 in number at a time.

In other particulars like *Salpa*.

This section includes three species :—

With no large appendages at posterior end in solitary form. Aggregated form with anterior end narrower than posterior. *I. cordiformis-zonaria*, Q. & G.-Pall. [(Atl., Ind. O., Pac., Med.)
With a pair of large appendages at posterior end in sol. form. Agg. form with anterior end wide 1

1 Appendages plain, directed laterally, no longit. ridges on test. Agg. form with aperts. terminal. *I. costata-Tilesii*, Q. & G.-Cuv. (Atl.) [Ind. O., Pac., Med.)
Appendages serrated, directed posteriorly and terminating longitudinal ridges of test. Agg. form with apertures dorsal 2

2 Muscle-bands wider than the interspaces in agg. form. *I. hexagona*‡, Q. & G. (Pac., Ind. O.)
Muscle-bands much narrower than interspaces; only agg. form known. *I. nitida*, Herdm. (Pac.)

Most of the remaining species of Salpidæ which have been described or figured have been shown by Traustedt, or others, to

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* *Salpa quadrata*, Herdm. (N. Atl.), appears to be closely related to this species. The single 'Challenger' specimen (sol. form) had a remarkable club-shaped dorsal lamina; but that may be an individual abnormality.

† This, however, is not the *Iasis* of Savigny, the type of which was *Salpa cylindrica*.

‡ *Salpa musculosa*, Herdm. (Atl.), and *S. echinata*, Herdm. (Atl., Pac.), are probably closely allied to this species; but as the condition of their embryos is not known, they cannot be placed with certainty in this genus. The solitary forms only are known, and they differ in several particulars from that of *Iasis hexagona*.

be more or less certainly synonyms of one or other of the preceding species. The following, however, are imperfectly known, and still in doubtful case, and may some of them be distinct species:—

Salpa antarctica, Meyen. (A. Arct.)
S. anthelophora, Pér. & Les. (Atl.)
S. aspera, Cham. (N. Pac.)
S. bicornis, Cham. (Mal.)
S. caerulea, D. Ch. (Med.)
S. dubia, Cham. (N. Pac.)
S. emarginata, Q. & G. (Pac.)
S. hexagona, Dall. (N. Atl.)
S. inermis, Q. & G. (Pac.)
S. pyramidalis, Less. (?)
S. rhomboides, Q. & G. (Pac.)
S. rubrolineata, Less. (?)
S. tricuspida, Less. (?)
S. tricuspidata, Q. & G. (Pac.)
S. vaginata, Cham. (Mal.)

Family II. OCTACNEMIDÆ, *Herdman*, 1888.

Body flattened antero-posteriorly (?), probably attached.

Test gelatinous, thin, transparent.

Branchial sac with no stigmata or openings into the peribranchial cavity.

Alimentary canal placed dorsally and posteriorly; coiled up along with the reproductive organs to form a visceral mass or "nucleus."

Life-history unknown.

This family contains only the remarkable deep-sea genus *Octacnemus*, discovered during the 'Challenger' Expedition.

OCTACNEMUS, *Moseley*, 1876 (*Herdman*, 1888).

Body flattened antero-posteriorly (?), probably attached by the posterior end. Margins of body prolonged to form 8 conical radiating processes.

Test gelatinous, thin, transparent.

Mantle slight. Musculature in the form of narrow muscle-bands, which are mainly confined to the conical processes

Branchial sac with its length directed dorso-ventrally, and having

merely imperforate pits in its walls, and no direct connection with the peribranchial cavity.

Dorsal lamina unrepresented.

Alimentary canal coiled up along with the reproductive organs to form a visceral mass (the "nucleus"), placed at the dorsal edge of the posterior end of the body.

Gonads hermaphrodite.

This genus contains the very aberrant abyssal form *Octacnemus bythius*, Moseley, obtained during the 'Challenger' Expedition in the South Pacific from depths of 1070 and 2160 fathoms.

Order III. LARVACEA, *Herdman*, 1882.

The Larvacea, or Copelata (Gegenb.), are free-swimming pelagic forms, provided with a large locomotor appendage (the "tail"), in which there is a skeletal axis (the urochord).

A relatively large test (the "Haus") is formed with great rapidity as a secretion from the surface of the ectoderm; it is, however, merely a temporary structure which may be cast off and afterwards replaced by another.

The branchial sac is simply an enlarged pharynx with two ventral ciliated openings (stigmata) leading to the exterior. These open independently on the ventral surface. There is no separate peribranchial cavity.

The nervous system consists of a large anterior and dorsally placed ganglion, and a long nerve-cord with smaller ganglia, stretching backwards from it over the alimentary canal to reach the tail, along which it runs on the left side of the urochord.

The alimentary canal lies behind the branchial sac, and the anus opens ventrally on the surface of the body in front of the stigmata (or atriopores).

The gonads are placed at the posterior end of the body.

Gemmation does not take place, and alternation of generations and metamorphosis do not occur in the life-history.

This group contains a single family, the Appendiculariidæ, all minute tailed free-swimming forms, which have undergone comparatively little degeneration, and consequently correspond more nearly to the tailed-larval condition than to the adult forms of the other groups of Tunicata.

Family APPENDICULARIIDÆ, *Bronn*, 1862.

Body more or less ovate, with the longer axis antero-posterior, and having a large appendage (the tail) attached to the ventral surface. The branchial aperture is anterior.

Test periodically developed into a very large investing-capsule, which is after a time cast off from the body.

Branchial sac is simple, and has only two openings, which are placed one on each side of the ventral edge, and lead to separate atrial apertures.

Nervous system consists of a large ganglionic mass placed dorsally near the anterior part of the body, and a nerve-cord with ganglionic thickenings which is continued posteriorly and ventrally into the appendage.

Alimentary canal lies posterior to the branchial sac. The anus opens on the exterior of the body.

Gonads, like the anus, independent of the atrial apertures.

This family contains five genera *, which may be distinguished thus:—

	No heart, no endostyle, pharynx with 4 rows of ciliated processes.	**Kowalevskia.**
	Heart and endostyle, no such processes in pharynx	1
1	Body elongated and divided into two parts; fold of integument forming a hood	**Fritillaria.**
	Body compact, short; no hood	2
2	Rectum enormous, tail moderately long	**Appendicularia.**
	Rectum not very large, tail very long..	3
3	Body ovoid, not depressed....................................	**Oikopleura.**
	Body rhomboid, depressed	**Stegosoma.**

APPENDICULARIA (*Cham.* 1821), *Fol*, 1874.

Body contracted, depressed anteriorly, swollen posteriorly. No fold of integument forming a hood is present.

Tail moderate, measuring twice to thrice the length of the body.

Endostyle slightly curved.

Rectum enormous, larger than stomach and intestine together.

* *Vexillaria*, J. Müller, is a synonym of *Oikopleura*, and *Eurycercus*, Busch of *Fritillaria*. A remarkable form was described (no name) by Moss in 1871 as having stigmata in the wall of its branchial sac. If that is correct, and if the form really belongs to this family, it ought to be placed in a genus by itself. I would suggest for it the name *Mossia dolioloides*.

Probably this genus, in the restricted sense, contains only two or three species. The only one sufficiently described is *Appendicularia sicula*, Fol (Med.).

OIKOPLEURA (*Mertens*, 1831), *Fol*, 1872.

Body ovoid, contracted ; no hood present.

Tail long, measuring from thrice to four and a half times the length of the body. It is about four to six times as long as it is broad.

Endostyle straight.

The following are the better-known species of this genus. A number of others which have been named or referred to cannot be placed. The first-known species was *Oikopleura Chamissonis*, Mertens (N. Pac.). Another form frequently referred to is *O. flabellum*, J. Müll.

	The "Haus" almost globular ...	1
	The "Haus" not globular, usually ovate ...	2
1	With a pre-anal fold of integument ...	*O. spissa*, Fol. (Med.)
	With no pre-anal fold ...	*O. speciosa*, Eisen. (N.W. Eur.)
2	Stomach and intestine of a bluish or violet colour ...	3
	Alimentary canal not blue or violet ...	4
3	Body 1 mm. long ...	*O. dioica*, Fol. (Atl. & Med.)
	Body 0·2–0·5 mm. long ...	*O. cærulescens*, Geg. (Med.)
4	Body 1 to 2 mm. long ...	5
	Body about 4 mm. long ...	*O. cophocerca*, Geg. (Med.)
5	Body 1·8 mm. long ...	*O. rufescens*, Fol. (Atl., Med.)
	Body 1·1 mm. long ...	6
6	Body elongated, narrow, tail rather wide, mouth directed upwards.	*O. fusiformis*, Fol. (Atl., Med.)
	Body ovato-elongate, tail very narrow, mouth directed forwards.	*O. albicans*, Leuck. (Med.)

STEGOSOMA, *Chun*, 1888.

Body rhomboid, depressed.

Endostyle moderately large.

Stomach and *intestine* forming an arch over the liver.

This contains a single form named by Chun.

FRITILLARIA (*Q. & G.* 1833), *Fol*, 1872.

Body elongated, more or less constricted in the middle where the tail is attached. A fold of integument on the front of the body forms a "hood."

Tail short and wide, about once and a half as long as the body.

Endostyle curved.

The species which are sufficiently known can be distinguished thus :—

	The tail bifurcated at its extremity	1
	Tail not forked	2
1	With long posterior processes, forks of tail not narrow. *F. furcata*, Vogt. (Med.)	
	With short posterior processes, forks of tail narrow. *F. megachile*, Fol. (Med.)	
2	Body bent at an angle, mouth 6-lobed. *F. formica*, Fol. (Med.)	
	Body straight, mouth not lobed	3
3	Body 2·25 mm. long, stinging-cells in integument. *F. urticans*, Fol. (Med.)	
	Body 1·15 mm. long, no stinging-cells... *F. haplostoma**, Fol. (Med.)	

Kowalevskia †, *Fol*, 1872.

Body ovoid, truncated anteriorly.

Tail large, lanceolate and pointed.

Endostyle and *heart* absent.

Pharynx with four rows of ciliated processes.

Intestine absent, except the rectum.

This remarkable genus contains a single species, *Kowalevskia tenuis*, Fol, from the Mediterranean.

Appendiculariidæ have been found in nearly all seas of the world; but most of the forms recorded or preserved cannot now be referred to their proper species.

* *Appendicularia acrocerca* of Gegenbaur.

† This genus has such exceptional characters, that it might be separated from the Appendiculariidæ as a distinct family.

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END OF THE TWENTY-THIRD VOLUME.

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